Report submitted to USAID/Mali

MALI
An Analysis of the Benefits and Costs of Alternative Irrigation Investments

Under the
Integrated Water and Coastal Resources Management Indefinite Quantity Contract (No. LAG-I-00-99-00018-00, Task Order No. 806)

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Abbreviations and Acronyms

AfDB	African Development Bank
AFD	*Agence française de développement*
AGETIER	*Agence d'exécution des travaux d'infrastructures et d'équipements ruraux*
AIV	*Association inter-villageoise*
APCAM	*Assemblée permanent des chambres d'agriculture au Mali*
ARPON	*Amélioration de la riziculture paysanne à l'office du Niger*
AV	*Association villageoise* (village associations)
BEAU	*Projet besoin en eau*
BNDA	*Banque nationale de développement agricole*
CAE	*Centre agro-entreprise*
CFAF	CFA franc
CIRAD	*Centre de coopération international en recherche agronomique pour le développement* (France)
CGC	*Comité de gestion des casiers*
CIDA	Canadian International Development Agency
cm	centimeters
CMDT	*Compagnie Malienne pour le développement des textiles*
COMANAV	*Compagnie Malienne de navigation*
CP	*Comité paritaire*
CPR	*Comité de producteurs de riz*
CPS	*Cellule de planification et de statistique, MAEP*
CRRA	*Centre de recherche agronomique de Niono, IER*
CSP	Country Strategic Plan
DAD	*Développement agricole du delta*
DNAER	*Direction nationale de l'aménagement et de l'équipement rural*
DNAMR	*Direction nationale de l'appui au monde rural*
DRAER	*Directions régionales de l'aménagement et de l'équipement rural*
DRAMR	*Directions régionales de l'appui au monde rural*
DNGR	Rural Works Department
EDF	European Development Fund
EIA	environmental impact assessment
EU	European Union
GEAU	*Projet gestion de l'eau*
GRM	Government of the Republic of Mali
ha	hectares
HYV	high-yielding variety
IER	*Institut d'economie rurale*
IR	Intermediate Result
IRR	internal rate of return
kg	kilograms
km	kilometers
m	meters
MAEP	*Ministère de l'agriculture, de l'elevage et de la pêche* (formerly MDRE or MDR)
MASA	Mali Agricultural Sector Assessment

MDRE	*Ministère du développement rural et de l'environnement*
MIG	*Micropérimètres irrigués de groupe*
mm	millimeters
MT	metric tons
NRM	Natural Resource Management
O&M	operation and maintenance
ODRS	*Office de développement rural de Sélingué*
OHVN	*Office de la haute vallée du Niger*
ON	*Office du Niger*
OPEC	Organization of Petroleum Exporting Countries
OPIB	*Office du périmètre irrigué de Baguinéda*
ORM	*Office riz Mopti*
ORS	*Office riz Ségou*
PACCEM	*Projet d'appui à la commercialization des céréals au Mali*
PASAOP	*Programme d'appui au secteur agricole et aux organisations paysannes*
PDIAM	*Projet de développement rural integré en aval du barrage de Manantali*
PEIF	*Petites exploitations irriguées familiales*
PIV	*Perimètres irrigués villageois*
PNPE	*Politique nationale de protection de l'environnement*
PNIR	*Programme national d'infrastructures rurales*
PPIP	*Projet de promotion de l'irrigation privée*
PPIV	*Petits perimètres irrigués villageois*
PSSA	*Programme spécial de sécurité alimentaire*
PVAPD	*Projet de vulgarisation agricole en pays Dogon*
SDDR	*Schéma directeur du développement rural* (Master Plan for Rural Development)
SNDI	*Stratégie nationale de développement de l'Irrigation* (National Irrigation Development Strategy)
SO	Strategic Objective
SSN	*Service semencier national*
T	metric tons
UNDP	United Nations Development Program
URD/OC	*Unité de recherche développement/observatoire du changement*
USAID	United States Agency for International Development
VRES	*Valorisation des ressources en eau de surface*
WUA	water user association

1.0 Introduction and Background

1.1 Introduction

In 2001 USAID/Mali commissioned an assessment of the agricultural sector to assist it in preparing a Country Strategic Plan for the next ten years, 2003-2012. The assessment team from Abt Associates Inc., after a sweeping and thorough review of the entire sector, saw "enormous" potential in the irrigation subsector. Indeed, it presented investment in irrigation as the lead suggestion in its summary of major proposed interventions. However, the assessment team advised USAID to commission "a more comprehensive analysis of the benefits and costs of alternative irrigation investments" before it designed any activity in the irrigation subsector. This report is the result of that suggestion.

The report should be read in conjunction with Abt's *Mali Agricultural Sector Assessment* (MASA) of March 2002, which contains detailed information on rice, horticultural crops and other key subsectors that has not been duplicated here.

The irrigation study team conducted field work in Mali from September 3 to October 16, 2002. The members of the team were:

- Dr. Ron Gaddis, team leader and agricultural engineer,
- Salmana Cissé, rural sociologist,
- Hamidou H. Kebé, agricultural engineer,
- Alpha Oumar Kergna, agricultural economist,
- Paul Marko, agronomist,
- Charles Steedman, economist, and
- Yaya Togola, agronomist.

Study Team and technicians discuss controlled flooding system at Djenné

CARE/Mali supplied the Malian members of the team and provided absolutely invaluable logistic support, including vehicles and office space. Jean Michel Vigreux, Director of CARE/Mali, gave the team the benefit of his experience in Mali and his knowledge of the agricultural sector. His advice and counsel were extremely helpful. The USAID Accelerated Economic Growth team, led by Dr. Dennis B. McCarthy and Gaoussou A. Traoré, greatly facilitated the work of the team by providing clear direction and useful advice.

The report is divided into four sections. The remainder of Section 1 provides background information on the irrigation subsector, on Mali's national irrigation development strategy and on USAID's strategic plan for the 2003-2012 period. Section 2 analyzes the four principal irrigation systems in Mali. Section 3 compares the impact of these systems on output, food security, productivity and the environment. The final section recommends activities for USAID to pursue in the irrigation subsector.

1.2 Irrigation Potential in Mali

Mali is divided into four climatic zones that define the possibilities for rainfed agriculture and the necessity for irrigation. The choices as to which type of irrigation is appropriate for investment are different for each region of the country. More specifically, the characteristics of a particular site often limit the type of irrigation to the one choice which is practical.

The climatic zones may be described as follows.

- Soudano-Guinean, which is characterized as wooded savanna and forests in the south, covering six percent of the country. Annual rainfall normally exceeds 1200 millimeters with a growing season defined as more than 160 days. Rainfed agriculture is the dominant form of agriculture.
- Soudanian, covering twelve percent of the country, where rainfall is 600 to1200 millimeters and the growing season is 100 to 160 days. In this zone, irrigation is considered supplemental to rainfed agriculture.
- Sahelian, with 26 percent of the land, rainfall between 200 to 600 millimeters and a growing season of 15 to100 days. This zone is essentially the area known as the "interior or central delta" and is a separate climatic zone. The zone is considered to be an area where irrigation is essential because of unreliable and low rainfall.
- Saharan, comprising 51 percent of Mali's land resource, which is essentially desert with rainfall of less than 200 millimeters and a growing season of less than 15 days. Some form of irrigation must be utilized to grow a crop, as rainfall is insignificant.

By far the most significant water source for irrigation in Mali is the Niger River. With its headwaters in Guinea, approximately 40 percent of the river's 4,200 kilometers is located in Mali as it makes a large loop to the northeast and then turns southeast to empty into the ocean in Nigeria. Part of the upper and middle basins of the Niger are in Mali. The Niger and its tributaries, principally the Sankarani and Bani Rivers, provide a water source that could eventually be harnessed to irrigate a substantial area within Mali. To date only a small portion of that area has been developed for irrigation.

The Niger delivers some 30 billion cubic meters of water a year, more than half of it—16 billion cubic meters—in the peak months of September and October. From February through April, however, river flow slows to a comparative trickle of only about one billion cubic meters over the three-month period. Table 1.1 shows how much water was drawn from the Niger for irrigation purposes (and as a result of evaporation at the Sélingué dam) during the 1989-1997 period.

Table 1.1. Irrigation Use of the Niger River, 1989-1997

Irrigation Scheme	Volume Drawn (million cubic meters)	Percentage of Total Flow
Sélingué	34	0.1
Baguinéda	215	0.7
Office du Niger	2,562	8.5
Offices Riz Ségou & Mopti	398	1.3
Evaporation at Sélingué	569	1.9
Total Volume Drawn	3,778	12.5

SOURCE: M. Kuper, J.-C. Olivry, A. Hassane, "Le fleuve Niger: Une ressource à partager" in *L'Office du Niger, grenier à riz du Mali*.

A 1982 study by the United Nations Development Program (UNDP) identified 2.2 million hectares that could potentially be irrigated if appropriate infrastructure were created. As shown in Table 1.2, more than half of this area, about 1.3 million hectares, lies in the central regions of Ségou and Mopti, where both the "dead" and "living" inland deltas of the Niger are located. The former consists of low-lying areas that were flooded by the river in ancient times. The latter is the floodplain of the river today. Portions of the dead delta were turned into irrigated land some years ago by the construction of a diversion dam at Markala that now dumps about 8.5 percent of the Niger's volume into the canals of the *Office du Niger* (ON), an irrigation scheme initiated in the 1920s (see Appendix A).

Table 1.2. Area Potentially Irrigable and Area Irrigated, by Region

Region	Area Potentially Irrigable (ha)	Area Cultivated Irrigated in 1999-2000 (ha)
Kayes	90,000	12,963
Koulikoro	110,000	22,439
Sikasso	300,000	47,517
Ségou	500,000	117,371
Mopti	810,000	150,814
Timbuktu	280.000	33,997
Gao	110,000	33,212
Total	2,200,000	418,313

SOURCE: MDR (Adama Coulibaly), "*Le développement rizicole au Mali*," page 7 and Annexe III.

As shown in the table, almost 400,000 hectares of potentially irrigable land lie near the Niger River in the northern Regions of Timbuktu and Gao, and around the lakes to the west of Timbuktu itself. The remainder is divided between the upper valley of the Niger southwest of Bamako (110,000 ha in the Koulikoro Region), the Senegal River valley in the west (90,000 ha in the Kayes Region) and Mali-Sud in the Sikasso Region, where rainfall heavier than in the rest of the country can be captured in inland valley basins (*bas-fonds*) for irrigation use (300,000 ha).

The figure of 2.2 million potentially irrigable hectares is theoretical and deceptively large because some significant portion of this area cannot realistically be brought under irrigation. As new areas are developed and irrigated, other areas that had potential will no longer be feasible. The 1982 UNDP study prudently limited the potential for the ON to 250,000 hectares, rather than repeating the figure that is often cited—960,000 hectares—because not enough water could be diverted from the Niger to bring that much surface under cultivation. The upper limit of the ON's capacity is still being debated.

The irrigated area figure shown in Table 1.2 above is also somewhat misleading. It includes 78,033 hectares of inland valley basins, known as *bas-fonds*, that are considered to be "irrigated" but in fact have not been endowed with irrigation structures. The figure does not include freely flooded areas (*submersion libre*) or flood recession areas. The reality is that even when all *bas-fonds* are included, undeveloped as well as developed, less than ten percent of the theoretical potential is currently being irrigated.

It is difficult to obtain a reliable estimate of the area that can be considered irrigated. The MDR workshop presentation in February 2002 cited above presents the following breakdown of irrigated rice production drawn from operational reports of the national agricultural extension agency, DNAMR. The irrigated areas almost without exception grow rice in the rainy season.

Table 1.3. Rice Production by Irrigation System, 1999-2000

Irrigation System	Area (ha)	Production (T)	Yield (kg/ha)
Total water control	75,461	363,007	4,811
Partial control	45,202	60,801	1,345
Bas-fonds	82,319	107,865	1,310
Total	202,982	531,673	

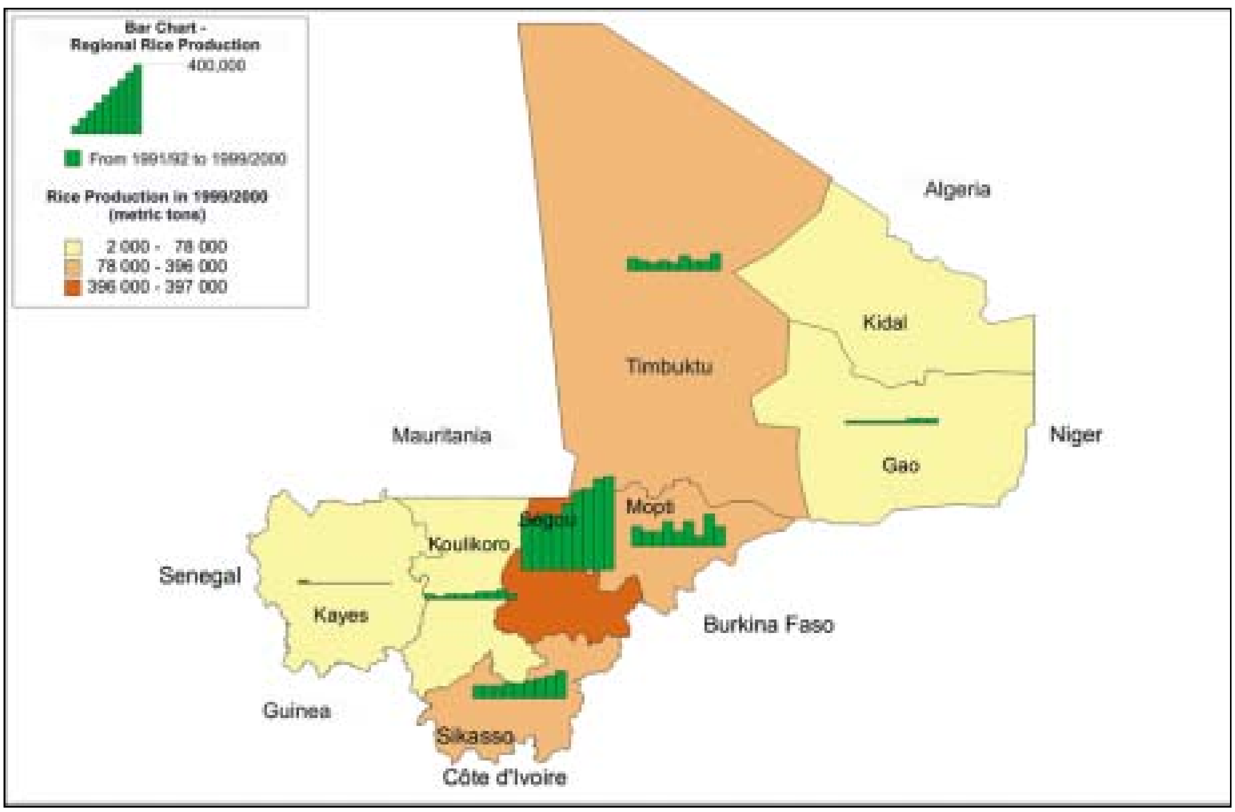
SOURCE: MDR (Adama Coulibaly), *op. cit., page 7.*

A total of roughly 200,000 irrigated hectares seems accurate. The study team obtained the estimates shown in the table below in the course of its work. These figures are rounded to the nearest hundred. Figures for *bas-fonds* in the Kayes Region and the OHVN zone of the Koulikoro Region were not available and are not included. The grand total is therefore somewhat more than what is shown. Table 1.4 provides a breakdown of partial control and *bas-fonds* different from that in Table 1.3. This is probably because the distinction between the two is often blurred. Descriptions of the subsystems mentioned in Table 1.4 are found in the following section and in Section 2.0.

Table 1.4. Estimates of Irrigated Area, 2002

Irrigation System	Area (ha)
Total Water Control	
Office du Niger (*casier*)	54,400
Office du Niger (*hors casier*)	5,200
Office du Niger (SUKALA)	5,800
Baguinéda	3,000
Sélingué	800
VRES project, Mopti	1,300
PIV Timbuktu	2,000
PACCEM project, Diré	3,000
Sub-total	75,500
Partial Control	
Office Riz Ségou	34,100
Office Riz Mopti	33,800
DAD project, Djenné	49,000
Sub-total	116,900
Bas-fonds	
Bas-fonds, CMDT zone	8,100
GRAND TOTAL	200,500

Map A. Rice Production



SOURCE: MDR, *Receuil des statistiques du secteur rural*, mars 2001, page 35.

1.2.1 Irrigation Systems

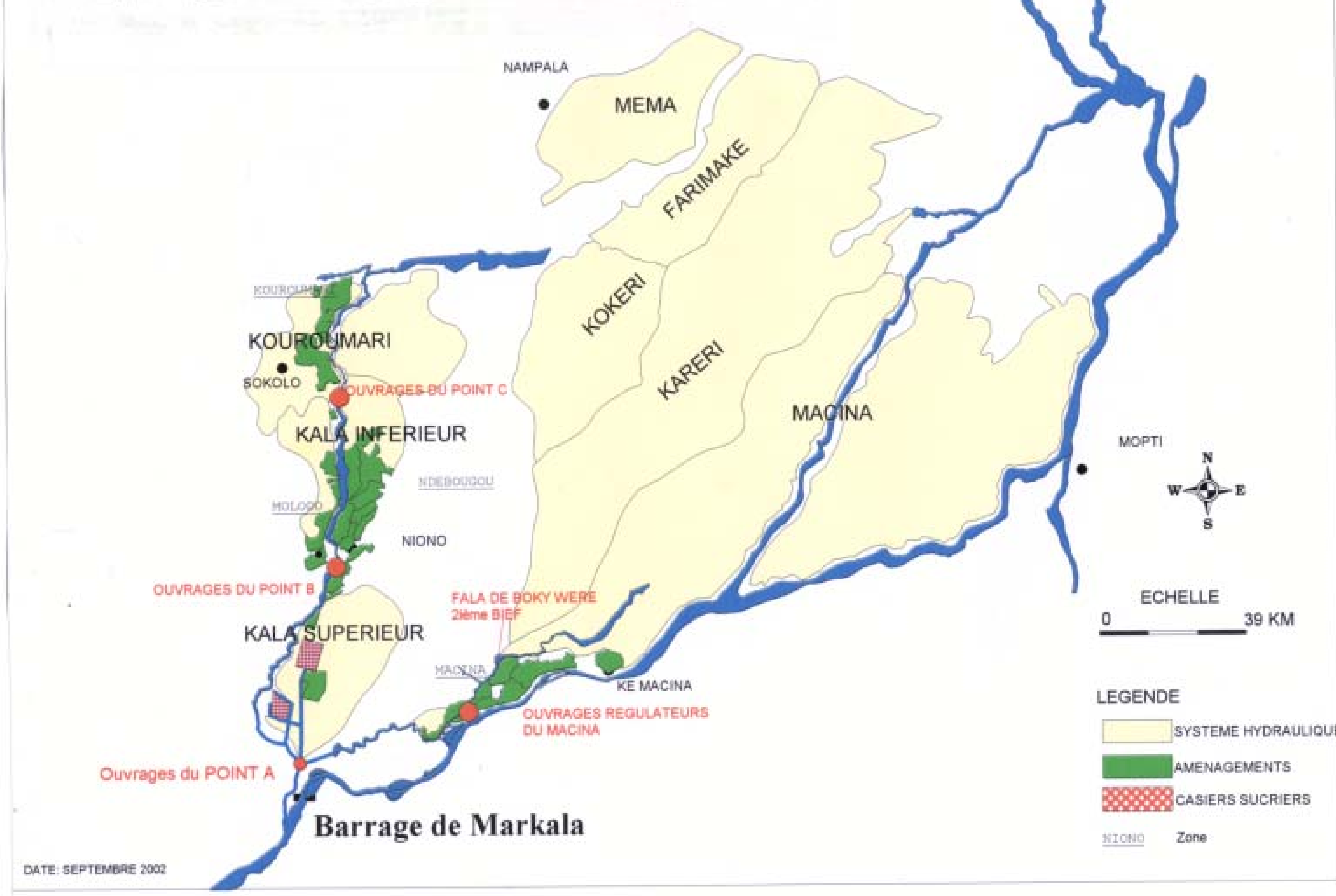
The free flooding (*submersion libre*) system that is traditionally used on the floodplain of the Niger and Bani Rivers is completely at the mercy of the climate and of the extent and duration of the annual flood because there are no control structures. In order to be successful, the system requires that there be enough rainfall to allow rice plants to germinate and that flooding occur at an opportune time, not so early that the young plants drown and not so late that inadequate rainfall allows them to die. As a result of this risky environment, yields and production are around 500-600 kilograms per hectare and can vary widely from year to year.

At the opposite end of the spectrum lie the systems—large-, medium- and small-scale—that employ gravity flow and pump irrigation. In Mali these systems are usually denoted by the term "total control" (*maîtrise totale*). For an irrigation system actually to be one of total control, it needs to include all of several components. These are:

- Reliable and adequate source of irrigation water of suitable quality;
- Efficient delivery system to the larger irrigated area;
- Equitable and efficient distribution system within the irrigated area;
- Uniform distribution with the irrigated plot;
- Utilization of a functional system of drainage and outlets;
- Organizational ability to distribute water, within the larger area, characterized by:
  - timeliness or at the time the farm judges water is needed by the crop,
  - flexibility or the ability to differentiate between water needs of individual farmers, and
  - appropriate quantities or the amount needed at the various stages of crop growth;
- Organizational ability to maintain the overall system, characterized by:
  - Prevention of degradation of the source (dam, diversion dam or motor pump),
  - Upkeep of the main canals or water basin for pumped water,
  - Preservation of the condition of primary, secondary, tertiary and quaternary canals,
  - Control structure upkeep, and
  - Upkeep of the drainage system canals and structures; and
- Prohibition of damage due to entry into the irrigated area of unwanted floodwater or rainfall runoff.

The Office du Niger is by far the most important of the large-scale systems, where perimeters exceed 1,000 hectares. The ON presides over developed and undeveloped portions of the dead delta (see Map B). The ON, a state-owned industrial and commercial enterprise, has in the past decade ceded some of its control over the system. The ON has turned operation and maintenance of tertiary canals over to producer groups, for example, and has privatized some of its operations, notably rice milling. Within the boundaries of the ON but operating independently are the two SUKALA sugar mills with about 5,000 hectares devoted to sugarcane production.

Map B. Irrigated and Potentially Irrigable Areas of the Central Niger Delta



Since 1973 the cultivated area under the aegis of the ON has increased only by a third, from 40,000 to 54,400 hectares,[1] but the average paddy yield has tripled to six tons per hectare, and paddy production has increased by almost 400 percent, reaching 325,000 tons in 2000-2001. These dramatic improvements are attributable in part to the rehabilitation of 30,000 hectares with substantial help from Mali's development partners (donors), to improved cultural practices such as transplanting, to much greater use of inputs, and to the relaxation of control by the ON.

Other large-scale, fully controlled systems are the perimeters associated with the Sotuba dam at Baguinéda and with the Sélingué dam on the Sankarani tributary of the Niger, near the Guinea border. Baguinéda was once considered to be part of the ON but is now a separate Office with 3,000 hectares under cultivation. Below the Sélingué dam 800 hectares have been developed to date, and there are over 2,200 additional hectares in four downstream areas that have been the subject of technical irrigation studies financed by the African Development Bank (AfDB). All of these large-scale systems divert the water of the Niger and its tributaries into irrigation canals.

One difference between these large-scale perimeters and the medium- and small-scale village perimeters (PIV) that are also considered to operate with total water control is that village groups rather than government agencies manage them. Another difference is that they rely on pump lift rather than diversion of flow. In the Timbuktu and Gao Regions, village groups have developed medium-scale perimeters of 500 hectares or more using Archimedes lifts. Schemes of this size often give rise to land tenure conflicts as well as posing difficult management and maintenance problems.

The small-scale village perimeter (PPIV) system is less ambitious. It relies on diesel-powered pumps to lift water from the river into the perimeters. Small perimeters ranging from only six to 30 hectares have recently been attaining paddy yields in the five-ton range. Their smaller size makes them less vulnerable to land tenure or other kinds of conflict. The European Union and the World Bank are actively promoting them in the Mopti Region and farther north.

Falling between total water control and free flooding are two systems that partially control river flooding. One system, called controlled flooding (*submersion contrôlée*), employs small structures to retain water and guide its flow without, however, being able to control the amount that reaches individual parcels. This system is found in the Ségou and Mopti Regions. Two government agencies, *Office riz Mopti* (ORM) and *Office riz Ségou* (ORS), have been developing new areas for it since the 1970s and encourage the use of animal traction and selected seed. In the south there are plains that can be irrigated under partial control from Niger tributaries such as the Lotio. Because water control is not total and because rainfall and the river crest can vary considerably in amount and in timing, the paddy yields of this system are unpredictable. Yields average less than two tons and sometimes fall as low as one ton. About 113,000 hectares benefit from controlled flooding.

A distinct system that relies on the collection of rainwater in streams rather than on river floods is the inland valley bottom or *bas-fonds* system, which is found in the higher rainfall areas,

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1 This figure is for rainy season cultivation in the ON's irrigated sectors (*casiers*). It does not cover off-season production, which came from 6,465 ha in 2001-2002, nor does it include land cultivated by ON farmers outside the irrigated sectors (*hors casiers*). In 2001-2002 this area amounted to 5,185 ha.

particularly in the southern zone dominated by cotton production under the aegis of CMDT (*Compagnie Malienne pour le développement des textiles*). The Kayes Region is also endowed with *bas-fonds*. One attractive aspect of this system is that it is largely under the control of women, who produce rice to nourish their families and also sell surpluses to augment family income. Another positive attribute is the relatively low cost of building control structures. It is clear, however, that these structures must be both precisely placed and well constructed to be able to do the job. This system covered over 80,000 hectares in 1999-2000, as shown in Table 1.3, though other estimates have been lower—30,000 hectares in the 2000 update of the Master Plan for Rural Development (SDDR) and 37,000 in the USAID Sector Assessment (MASA). According to the SDDR, there is potential for developing in excess of 400,000 hectares using *bas-fonds*.

Flood recession agriculture (*culture de décrue*) prevails in the Timbuktu Region. This system is concentrated around a series of lakes and ponds—Lakes Tagatji, Horo, Faguibine and Tanda, for example. An estimated 60,000 hectares are farmed with this method. Since no control structures are involved, this is really not an irrigation system, though it is sometimes lumped together with other systems under the heading of "irrigation." This report does not include a discussion of flood recession agriculture.

This report analyzes four major systems:

- Large-scale irrigation by gravity flow (*grande irrigation*);
- Controlled flooding or irrigation with partial water control (*submersion contrôlée*);
- Irrigated village perimeters (*petite et moyenne irrigation*); and
- Rainfall runoff control irrigation of small valley basins and large plains (*bas-fonds*).

Based on potential area alone, the two systems that offer the best possibility for substantial increases in coverage are large-scale, total water control and rainfall runoff control. Each has advantages and disadvantages that are examined later in the report.

1.3 Mali's Irrigation Development Strategy

With input from its development partners, notably expressed in a four-day workshop held in Bamako in September 1998, the Malian government published its national irrigation development strategy (SNDI) in August 1999. The SNDI was conceived as an integral part of other, related national strategies and policies. These are the Master Plan for Rural Development (SDDR) of 1992, the Accelerated Growth Strategy of 1997, the National Strategy for Poverty Reduction of 1998, the National Environmental Protection Policy (PNPE) of 1998 and the national decentralization policy.

The Accelerated Growth Strategy is pertinent because, in aiming to assure the country's food security by 2010 through increased agricultural production, the strategy calls for improving irrigation infrastructure and strengthening the capacities of the rural population. The SNDI is considered to be one of the primary instruments for achieving this goal. For its part, the National Strategy for Poverty Reduction proposes innovative actions to attack the fundamental causes of poverty and give new opportunities to poor and vulnerable segments of the population. The priority elements of the poverty reduction strategy include the following.

- Developing small-scale irrigation and off-season agriculture to increase employment and income levels among the poor;
- Putting in place a transparent system for managing irrigated land; and
- Promoting small-scale village irrigation and private irrigation schemes in food-deficit zones where the poor are heavily concentrated.

The government's PNPE has some specific objectives that concern the irrigation subsector. In essence, they favor decentralized, participative management of natural resources and seek a larger role for local government units and producer associations. Similarly, Mali's decentralization policy calls for the government to disengage progressively from several areas where it now intervenes, allowing local government units, the private sector and community groups to take over. These two policies make it clear that the kind of top-down, centralized management that was for decades the hallmark of the Office du Niger is no longer appropriate. In effect, they call for an accelerated transfer of irrigation management to water user groups. The SNDI sees itself fitting within the logic of decentralization and thus proposes to help rural people take new initiatives and become more creative.

1.3.1 Subsector Diagnosis

In its diagnosis of the irrigation subsector, the SNDI makes the following points.

- In the ON, the perimeter rehabilitation program, which has been underway for several years, could cut water consumption for rice production from as much as 44,800 cubic meters per hectare to 15,000 cubic meters (SDDR, 16).
- A 1981 study of water needs and management indicated that the basic infrastructure then in existence would allow for irrigated rice production on 105,000 hectares in the ON, entailing an off take of 200 cubic meters per second at the Markala dam.
- Creation of mid-sized perimeters of 100 to 500 hectares with total water control is exorbitantly expensive at 5 to 7 million CFAF per hectare because a dike is required to protect against flooding when the river crests.
- Partial water control structures (*submersion contrôlée*) are improvements over uncontrolled submersion, but they do not produce much; in fact they have fallen far short of what had been expected, having encountered problems with soil impoverishment, weed infestation and widely varying river crests and rainfall.
- However, the widespread abandonment of these partial control structures as a result of lack of water in recent years has been a mistake, because in certain zones they are a rational way to improve production; besides, they can be an intermediate step to the development of irrigated village perimeters (PIV).

- Flood recession and partial control together cover 65 percent of irrigated land; these techniques need to be reevaluated technically and economically; in some cases conversion to total control can be envisioned.
- Development of *bas-fonds* has been supported by many organizations, all professing to use a participative approach but having quite different methods; while this type of irrigation is relatively inexpensive at 500,000 to one million CFAF per hectare, yields are low (1.6 to 2.5 tons per hectare) and production is poorly organized.
- Development partners have provided technical and financial assistance in the subsector but because there was no real national policy on irrigation, the partners have tended to work autonomously, following their own procedures.
- In recent years land developed for irrigation has increased at a six percent annual rate while the irrigated area actually cultivated has declined by 3.5 percent annually; the decline results from the abandonment of flood recession and partial control areas, along with the degradation of total control schemes, particularly village perimeters (PIV), for lack of maintenance.

1.3.2 Constraints

Turning to constraints to the development of irrigation, the SNDI presents five separate categories of constraint:

1. Economic and financial
2. Linked to perimeter design, management and maintenance
3. Linked to agricultural production
4. Institutional, legal and regulatory
5. Environmental

The following table summarizes them.

Table 1.5. Constraints to the Development of Irrigation

Constraints	Causes
High cost of irrigation infrastructure	• Lack of participation by beneficiaries in design and construction of infrastructure • Poorly adapted construction equipment
Lack of finance and limited access to credit	• BNDA reluctance to lend medium term • Absence of land titles limits eligibility for credit
Substandard construction	• Low levels of expertise • Deficient planning and implementation • Improvised construction by farmers
Poor maintenance management	• Unrealistic water system user fees (*redevances*) • Poor definition of roles • Inappropriate practices
Inefficient water management	• Poor choice of equipment • Lack of organization of water users on tertiary structures

Constraints	Causes
Incompetence of management committees and village associations (AV)	• Illiteracy • Lack of training • Poor social cohesion • Lack of incentives
Unpaid water system user fees (*redevances*)	• Lack of transparency in use of fees • Lack of sanction for non-payment
Lack of inputs and equipment	• Inadequate seed multiplication and quality control • Absence of fertilizer suppliers
Little off-season production and lack of diversification away from rice	• Seasonal overlap because of long-maturing varieties • Failure to perform operations on time • Lack of interest in, technical knowledge of, advice on and markets for other crops
Inadequate extension services	• Imbalance between responsibilities of government services and resources available to them • Chambers of agriculture little involved or even present in some zones
Inadequate protection of land rights	• Absence of land titles on perimeters • Complex and expensive procedures for obtaining title • Conflicts between traditional and modern jurisdictions
Incomplete water legislation	• Water Code, developed in 1986 and enacted into law in 1990, has never been applied on the ground
Negative impact on the ecosystem	• Excessive draw down of water • Shunting of used water to low-lying areas • Deforestation
Soil degradation	• Increased salinity and alkalinity of soils • Extraction of mineral elements • Degradation of physical properties
Conflicts between irrigators and herders	• New perimeters obstruct cattle corridors • Increased herd size
Deterioration of health and sanitary conditions	• Domestic uses pollute waters in secondary and tertiary canals • Around perimeters, increased population lacking sanitary structures and education

SOURCE: SNDI, pp. 22-27.

1.3.3 Medium- and Long-term Needs

The SNDI estimated domestic demand for the principal irrigated crops. Rice is the most important of these. When rainfed rice is added, national production has exceeded 600,000 tons of paddy (or 400,000 tons of rice) since 1996-1997. (The Appendix C tables provide production data on rice and other crops.) Close to 50 percent of the rice that is produced domestically and about 75 percent of what is marketed comes from the ON. The SNDI estimated domestic consumption to be 470,000 tons annually. This was 40,000 tons more than was produced in 1997-1998, when paddy output reached 663,000 tons. With a high rate of urbanization and a continuing shift of consumer tastes from coarse grains to rice, domestic demand is increasing by four percent a year, the SNDI estimates. If so, by 2010 Mali will need an additional 260,000 tons of rice or 400,000 tons of paddy (SNDI, 29).

The SNDI makes the assumption that one-quarter of this increase can come from greater productivity on existing irrigated areas. Producing the remainder would require development of (and production on) about 75,000 additional hectares by 2010. Concerned that only about 1,000 hectares under total water control were being added each year, the Government of Mali (GRM) established a goal of 30,000 new hectares in the five-year period from 1998 to 2002. These are included in the total of 75,000 hectares. A total of 19,435 hectares had been developed under the program by the end of 2001.

1.3.4 Areas of Emphasis

The goals of the strategy enunciated in the SNDI document are food security, improved nutritional status for vulnerable groups, foreign exchange savings and higher incomes for the rural population. More specifically, the strategy aims, among other things, to:

- Redefine the role of various actors in the subsector.
- Support interventions that are demand-driven, whether by communities or private investors.
- Define an investment policy.
- Give priority to total water control schemes.
- Intensify and diversify irrigated production.
- Make rice cultivation in *bas-fonds* profitable.
- Establish an applied research program on irrigation.

The strategy elaborates on each of these points. With regard to roles, it sees a need to clarify those of decentralized government services and of local government units. It wants to see affirmation of the role of DNAER, the central government entity responsible for irrigation, as coordinator of the activities of donors and investors.

Concerning investment policy, the SNDI sees government involvement in perimeter development falling into three categories:

1. For community perimeters, the beneficiaries would have to participate very actively in the design and construction of the perimeter. Nonetheless, the government would cover most of the investment, down to the tertiary canal level, including land clearing and leveling that is beyond the capacity of the community.
2. For private perimeters, the government would negotiate its level of participation, which would normally be limited to construction of primary infrastructure.
3. For groups that have expressed a desire to irrigate but lack financial resources—such as youth, early retirees and former rebels—the government would develop perimeters and then recover its investment in part through a lease-purchase scheme.

In opting to give priority to total control schemes, the SNDI concludes that partial control and flood recession irrigation, because of mediocre results and high levels of risk, can be justified only under certain conditions, such as offering a high degree of security or being the prelude to total control. This would have to be evaluated on a case-by-case basis.

By diversification, the SNDI has crops other than rice and sugar in mind: fruits and vegetables, wheat, tea and forage crops. Speaking of *bas-fonds*, where in fact crops other than rice are also grown—notably potatoes, sweet potatoes and maize—the SNDI is drawn to them by the relatively low cost of building structures that capture rainwater runoff and redirect it in ways that raise the water table in low-lying areas. Other than suggesting that farming these areas be better organized and there be better access to inputs, the SNDI offers no suggestions on how to make them more profitable.

In the last 20 years there has been no applied research on irrigation in Mali. The SNDI considers it imperative to establish a program that would study aspects such as the water needs of various crops under different irrigation systems, the performance of different standards of operation of irrigated perimeters, and the economic and financial profitability of different systems.

1.3.5 SNDI Action Plan

The SNDI in the end comes down to an action plan, set forth in tabular form, that sets forth guiding principles, specific objectives, actions to be undertaken, the entity responsible, completion date and brief indicators. The six specific objectives are as follows.

- Make the design of irrigation structures more rational and reduce their cost.
- Encourage the involvement of nongovernmental entities and facilitate their access to finance.
- Improve the management of irrigated perimeters.
- Increase production and productivity on irrigated perimeters.
- Reform the institutional and legal framework for the subsector.
- Minimize negative environmental impacts and social conflicts created by irrigation.

Within these broad objectives, there is plenty of room for significant contributions by a USAID irrigation program. The next section briefly discusses how the USAID/Mali Strategic Plan for the 2003-2012 period can mesh with the SNDI.

1.4 USAID Country Strategy, 2003-2012

USAID/Mali's Country Strategic Plan (CSP) for the next ten years points out that "increasing economic growth and reducing poverty are central objectives for USAID and for the Government of Mali. To achieve these objectives, increased agricultural productivity with production risk reduction and trade are essential." (page 57). The strategy sees irrigation as a way to both increase productivity and reduce risk. Within the irrigation subsector itself, it sees diversification toward irrigated food crops for which Mali has comparative advantage as a way to reduce risk even further.

The USAID Mission's Strategic Objective (SO) No. 9 is Accelerated Economic Growth. Of the three Intermediate Results (IRs) for SO 9, the one that is of immediate relevance here is IR1 – Sustainable Production of Selected Agricultural Products in Targeted Areas Increased. As described in the CSP,

> This Intermediate Result proposes to reduce the production risk and enhance the productivity of the rice, horticulture and livestock subsectors through *investment in irrigation (rice and horticulture),* animal feed enterprises, together with training/capacity building throughout these subsectors and natural resource management (NRM). (Emphasis added.)

Echoing the sector assessment, the CSP considers "the potential for productivity enhancement and risk reduction through irrigation investments [to be] enormous." Dependence on the vagaries of rainfall in Mali, particularly in the zone where average annual rainfall may be little more than 400 millimeters, is obviously lessened. Furthermore, where total water control is possible, yields can be much higher. If water supply is adequate in the dry season, after a rice crop has been harvested, irrigated areas can be double-cropped with selected horticultural crops. This provides additional advantages. The CSP points out that women are responsible for most horticultural crop production in the ON. Incomes earned by women have a direct impact on poverty and family well being.

Considering the possibilities for USAID activities, the CSP includes "canal irrigation in the Office du Niger geographic zone, water catchment area [*bas-fonds*] irrigation, and small and medium scale irrigation." The CSP also envisages assisting farmers in irrigated areas "to seize the opportunities offered through increased access to production infrastructure (particularly in rapidly expanding irrigated areas) and technology, capacity building, together with reinforcing a sound natural resource management policy environment." Illustrative activities for the Accelerated Economic Growth Strategic Objective in the CSP include:

- Training farmer producer groups in business and management practices,
- Financing irrigation infrastructure, and
- Reforming irrigated land tenure.

In analyzing the principal irrigation systems in Mali in the following two sections of this report and in recommending an irrigation program for USAID/Mali in Section 4, the irrigation study team has kept in mind the kinds of intervention envisioned in the CSP and the objectives expressed therein.

2.0 Principal Irrigation Systems in Mali

2.1 Large-scale Irrigation by Gravity Flow

To assure gravity irrigation with "total water control", there are some basic requirements:

- A dam, for either water retention or water diversion, that dominates the area to be irrigated and capable of assuring adequate quantities of water will be available throughout the growing season(s);
- A canal system:
  - feeder, primary, secondary, tertiary and quaternary canals that can efficiently deliver water to individual parcels of land; and
  - control structures, efficient and effective gates, etc.;
- An adequate system of drainage;
- An effective system of water management; and
- An operational system of maintenance.

The costs of perimeters with these characteristics are extremely heavy in the initial stages. In Mali, the cost of preparation of one hectare within a perimeter for gravity irrigation utilizing total water control ranges from 3.5 to 7 million CFAF. This cost depends mostly upon the degree to which the type of construction selected is able to efficiently deliver water onto and within the irrigated parcels (lined canals, proper gates and leveled fields).

There are three systems that fit into this category: Baguinéda, the Office du Niger (ON) and Sélingué.

2.1.1 Baguinéda

The 3,000-hectare Baguinéda perimeter on the south bank of the Niger just below Bamako is supplied by the Sotuba dam, which antedates by almost two decades the Markala dam that feeds the ON. There are two parts to the settlements connected to the perimeter. *Baguinéda koro* (Old Baguinéda) houses the families that were installed by the colonial power, which created the perimeter with forced labor and then directed the cultivation of rice in the 1940s. Baguinéda Camp was set up for administration purposes after independence in 1961. Today, clustered around the perimeter are 21 villages whose inhabitants farm it as landholders or as laborers or as both.

Many of the families have occupations other than farming, such as carpentry, well digging or butchery. Farming for them is less a primary source of income than a way to reinvest savings from other occupations. Baguinéda is also well-known for attracting "weekend farmers" (*paysans de dimanche*)—government officials and wealthy merchants from nearby Bamako who farm more as a hobby than as an important source of income. Parcels of perimeter land are loaned and leased widely. Women often borrow land to grow horticultural crops or maize during the off-season. There is a considerable amount of farming done by hired hands, and as a result, given Baguinéda's proximity to the capital, farm labor is increasingly expensive.

OPIB (*Opération périmètre irrigue de baguinéda*) manages the perimeter. Serving as an intermediary between OPIB and landholders are village associations (AV), which are weak, largely because they were initiated from above and because many of the landholders are absentee. The functions of the AV are basically limited to collecting the system user fee (*redevance*), serving as an intermediary for input distribution, and reassigning land that has been withdrawn from those who have not paid the fee or who have failed to follow the prescribed practices (*cahier de charges*). During the rainy season there is competition for labor and equipment availability, while during the off-season conflicts may occur between farmers and fishermen or between and farmers and herders who want their animals to browse on the perimeter.

The heavy involvement of outsiders distinguishes Baguinéda from the ON. These landholders are seldom involved in decision-making and are not particularly concerned whether the farm workers they employ follow prescribed technical packages. The AV are rendered less effective than they might be because they are not in a position to stand up to influential landholders from Bamako. The fact that landholders resident in the Baguinéda villages sometimes become farm laborers for weekend farmers, who in turn resent paying high wages, makes the relationship difficult.


Unlined canal wastes water by seepage.

The environmental concerns about Baguinéda are similar to those in the ON. The presence of standing water exacerbates the incidence of malaria. Leakage of water from canals and drains leads to unsanitary conditions in the villages. On the other hand, there is a welcome trend toward the recycling of household garbage into compost for use on crops, particularly on horticultural crops, encouraged by the fact that chemical fertilizer is considered expensive.

2.1.2 *Office du Niger*

The history and recent evolution of the Office du Niger are treated in more detail in Appendix A. Suffice it to say here that the Office du Niger, created with great hopes in the 1930s, for a time became an albatross around the neck of an independent Mali. For more than twenty years after 1960, the ON was considered a “state within a state”—an inefficient, costly command structure with a large bureaucracy, low output and a disgruntled population of settler-farmers. In the last two decades, however, the Office has ceded some of its prerogatives to farmer groups and the private sector, rehabilitated a substantial segment of its irrigated land, and dramatically increased output and yields. All this was accomplished with massive financial and technical assistance from several donors.

These donors are now concerned that the way forward from here is not clear. Further change and expansion is needed, but there is not yet a government master plan to guide the way. As a result, the donors have jointly expressed their concern on a variety of issues and some of them are holding up future commitments until matters are clarified (see Appendix A).

The Office for its part has plans to develop as much as 120,000 additional hectares, largely through private investment. The ON has identified some areas (see Map C) where the primary irrigation and drainage structure already exists. The intention is for private investors themselves to undertake development of the secondary and tertiary infrastructure. Upon the successful completion, they may be granted title to the land. However, since the investors will be obliged to incur loans to cover what is estimated to be the 2.4 million CFAF cost per hectare of building infrastructure alone, it is likely that financial institutions making the loans will take title until the obligation has been fully paid. Whether there are financial institutions willing to make loans under these circumstances is another question, one that has been addressed in other studies.[2]

Indeed, the question of titles and land sales within the ON is a matter of some debate. The fact that the ON has been unable to attract any substantial investors for its expansion program may indicate that lack of titles is an issue. On the other hand, a recent book on the Office[3] comments that the Director General has taken a firm stand against buying and selling land within his domain. It also speculates, contrary to what other observers think, that many smallholder farmers feel more secure with traditional use rights, which they can keep as long as they farm the land. Be that as it may, unofficial land sales do occur within the Office.

Land Tenure

In the restructuring of the ON that began in the mid-1980s and accelerated a decade later, the government specified, in a Presidential decree issued in July 1996, four types of landholdings within the Office. For all four of them, the controlling hand of the ON is still evident. Smallholders who show that they have adequate labor and equipment may be granted a yearly farming contract, which is renewable by tacit consent, but they can be evicted from their land if they fail to meet their obligations for system maintenance or fail to pay the annual system user fee. They can also be evicted without apparent cause on three months notice by the Office. Those that have worked land on rehabilitated or newly developed perimeters for two years and prove that they have the capacity to intensify production can obtain a farming permit that gives them farming rights for an indeterminate period, provided they meet their obligations (*cahier des charges*). The permit allows them to transmit these rights to relatives who have worked the land with them. They can also be indemnified for any improvements they have made.

In fact, failure to pay the annual system user fee leads to frequent evictions. Those who are faced with it often take recourse in renting land to someone, unofficially, for one year at twice the amount of the fee (currently 63,500 CFAF per hectare). Ideally, this should allow the land lender to pay the fee the following year and start farming again, but it does not necessarily happen that way and the land lender often joins the ranks of landless farm workers in the ON.

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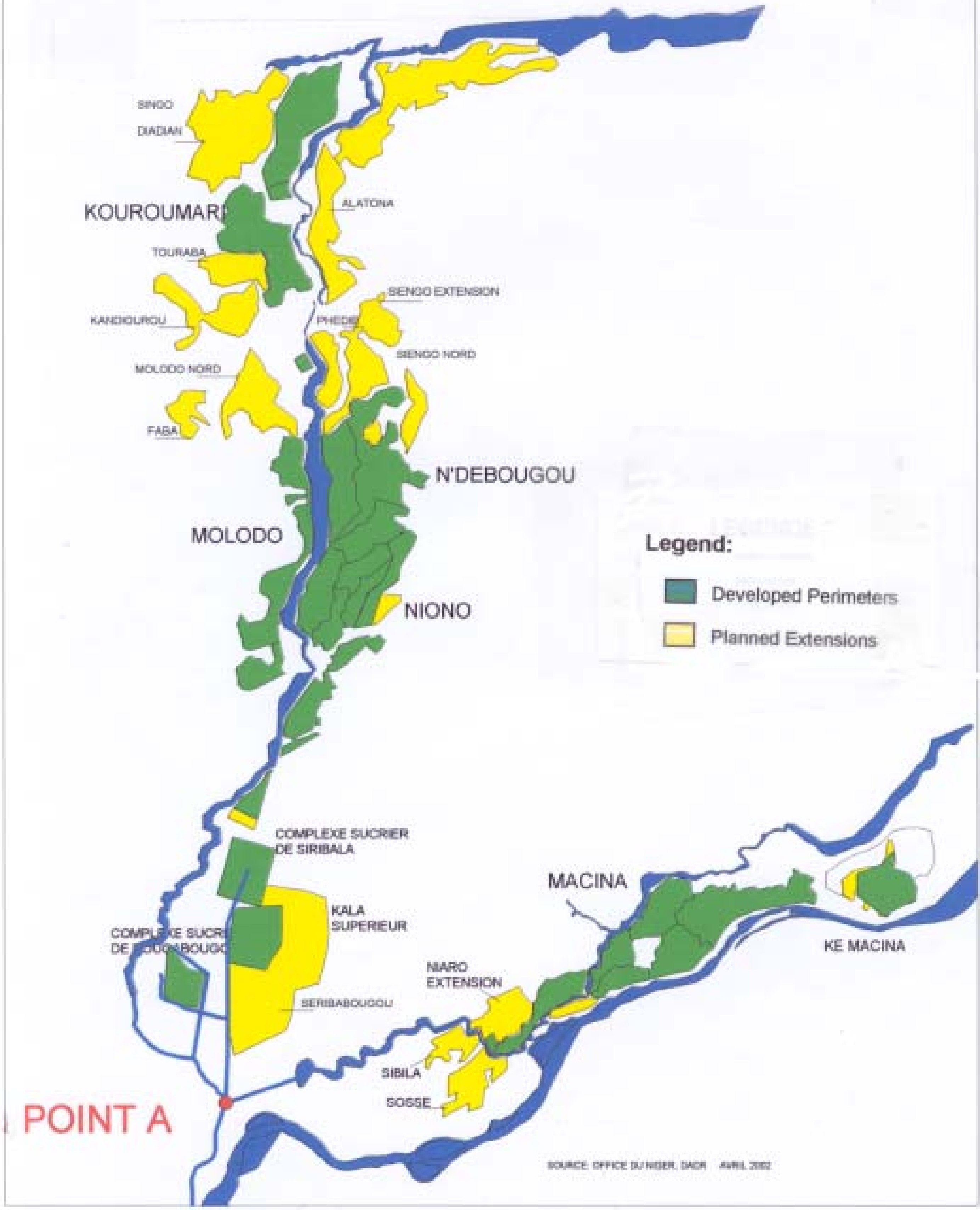
2 See, for example, J. Dirck Stryker, "Private Sector Investment in the *Office du Niger*: Proposal for a Non-Bank Financial Institution." Cambridge, MA: AIRD, January 2002. See also Aly Diallo, "*Les Contraintes à l'Investissement Privé à l'Office du Niger*. Table Ronde MICA-USAID/Mali, Bamako, October 1999.

3 Pierre Bonneval et al., *L'Office du Niger, Grenier à Riz du Mali*. Montpellier and Paris: CIRAD and Karthala, 2002.

Map C. Office du Niger: Developed Perimeters and Planned Extensions



The 1996 decree also provides for leases of 30 and 50 years. The former appear destined for smaller investors who intend to establish a production, processing or marketing enterprise on undeveloped land. Like smallholder farmers, they can be evicted for failure to meet obligations or pay the fee. The 50-year lease[4] appears to be for major investors who will establish production, processing, marketing or other agribusiness operations. They are responsible for building the entire secondary and tertiary infrastructure in accordance with the ON's technical specifications and under the ON's supervision. The lease is renewable after 50 years by mutual accord but if not renewed, the ON takes possession of all improvements without compensation.

One of the three joint committees established by the 1996 decree is the joint land management committee.[5] Its membership is equally divided between elected farmer representatives and designees of the Director General. While the committee examines cases of requests for land and of possible evictions, its powers are limited to making recommendations to the Director General, who makes the decision. Final control thus rests with the ON. Lack of transparency about these kinds of decisions is one the reasons why the donors, after investing very large sums in the Office since the 1980s, are hesitant to invest further until there is more transparency and a clearer course is charted for the future.

If these matters are resolved satisfactorily, there is good potential for building on the recent successes of the ON and expanding its production potential. In his recent report[6] to USAID/Mali, J. Dirck Stryker, assisted by Massa Coulibaly, concluded from their analysis that "it should be financially feasible to expand irrigation in the Office du Niger and to have all costs of investment in secondary and tertiary irrigation infrastructure and land development paid for by the farmers involved. However, this will require that yields be maintained close to the level of six tons per hectare, which is currently the average in the Office." In order to maintain yield at this level, they stated, transplanting would have to continue. This could be done even if there were continuing expansion of the use of power tillers (*motoculteurs*) but it would be more difficult if there were an attempt to use tractors on a large scale.

Water Use and Misuse

This report focuses on an important issue—the use of water in the ON and how it is paid for. Without doubt, the ability of the "bridge-dam" at Markala to raise the water level in the Niger River by 5.5 meters is a marvelous accomplishment. While it was surely costly to build at the time, it is an extremely valuable resource in the present day, decades later. However, to deliver the water diverted by raising the river surface, ancient dry channels (*falas*), which once inundated the area known as the "dead" portion of the delta, were utilized. The canal(s) thus formed are mostly unlined and often ill-defined as the water is conducted to the north and to the east. Approximately 57 percent of the water diverted into the Canal du Sahel in the rainy season

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4 A Chinese enterprise, COVEC, obtained a lease to develop 1,000 ha for an experimental farm and processing facilities in November 1998.

5 *Comité Paritaire de Gestion des Terres*. The two others are for canal management (*Comité Paritaire de Gestion des Fonds d'Entretien du réseau hydraulique secondaire* and at the level of each secondary canal, a *Comité Paritaire d'Entretien du réseau hydraulique tertiaire).*

6 Stryker, *op.cit.*

is lost before arriving at the tertiary canals. Some water is lost in refilling marshes along the way as well as to evaporation into the air and infiltration into the ground.

It is estimated that as much as 3.0 meters of water is used to grow a rice crop. Such high water use can actually be detrimental to yields. Ideally only 1.2 to 1.4 meters would be needed. Water would be available for nearly double the area if some there were some incentive reward to both farmers and ON system managers for the use of less water, i.e., more appropriate quantities.

One day, it will become imperative to systematically line and rebuild the canal(s) to reduce this lost water and use it for irrigating more area. When that happens, as much as 80 to 90 percent of the water could arrive at the tertiary canals. For now, this does not seem to be as economically feasible as it is to rehabilitate perimeters and to better utilize the water that is not lost en route. This may well mean lining the tertiary, secondary and primary canals within a perimeter to avoid wasted water. More effective gates of constant discharge, establishment of downstream control, and on-farm leveling should also be considered the norms in any new or rebuilt perimeters. On-farm leveling alone could raise the plot irrigation efficiency from an estimated 33 to 80 percent.

Social Concerns

The 152 village associations (AV) in the ON have been empowered by their ability to collect the system user fee and to distribute inputs to their members. Management of the AV is not strong, however, and these organizations have difficulty mobilizing their members to do canal cleaning and other tasks or even to attend meetings where decisions will be made.

Work on the perimeters of the ON demands high levels of labor input, particularly for transplanting. To meet these demands, landholder families often have recourse to non-resident extended family members for whom they provide lodging and food. The average size of the family is 12.4 persons. There is evidence of widespread use of underage children as field workers.

Producer Groups

Irrigation systems around the world have been moving toward greater participation by water user groups in operation and maintenance. Irrigation management transfer involves the relaxation of control by state-run entities and the assumption of greater and greater responsibility by farmer groups. It is a worldwide phenomenon that has both improved the efficiency of irrigation schemes and provided material as well as psychic benefits to farmers. In Mali, the ON is the principal location where, for historical and political reasons, management of the system has been closely guarded as a prerogative of the ON bureaucracy. The reforms of 1984, discussed in Appendix A, relaxed some of this control and began the process of handing responsibility for operation and maintenance (O&M) of tertiary canals to water user groups.

One of the constraints to greater empowerment of these groups in Mali, however, is the lack of legal standing for many of them. The 2000 update of the Rural Development Master Plan (SDDR) points out that only village savings schemes (*tons*) and cooperatives enjoy legal status. Village associations, village development committees and similar groups do not. This situation is of concern to the *Agence française de développement* (AFD), which notes that producer groups in the ON clearly need to improve their internal management capability as well. The AFD points out that farmer groups in the Timbuktu Region, trained with French help, are in general much better managed than those in the ON and are better able to assume new responsibilities. The SDDR, to the contrary, maintains that producer groups in the ON, along with those in the CMDT zone, are better organized and perform better than groups elsewhere.

Aside from the matter of internal management, it is an open question as to whether the farmer representatives who sit on the joint committees and the leaders of the various other village groups are sufficiently representative and are not intimidated into acquiescence with the ON's point of view. This makes it desirable that any training or development of participatory groups be aimed at empowering the farmer participants as well as training them intellectually and technically to fully comprehend what they are doing as irrigators and why such actions as cleaning tertiary canals, or reducing water losses in general, are important to them.

The Master Plan speaks of the transfer of certain tasks and responsibilities from the government (MAEP, *Ministère de l'agriculture, de l'elevage et de la pêche*) to the private sector and producer organizations. In the near term, the activities that have been and are being transferred include marketing, input supply, production of seed and plant material, crop processing, water supply, and savings and credit. While some transfers have been accomplished in the ON—rice mills were privatized in 1997 and rice marketing has followed—others have not. The state still plays an important role in input supply and seed production. Producer groups have been given responsibility for O&M on tertiary structures, but the wildly weed-infested state of as much as one quarter of the tertiary canals indicates that it has been a grudging transfer that has not been fully grasped by the recipients.

The RETAIL Project

This effort of the late 1980s and early 1990s, funded by France, incorporates technology for rehabilitation and redevelopment of 3,500 hectares. Some aspects of it are particularly worthy of replication. This is especially true of construction design and pioneer efforts in farmer participation in perimeter and water management. One of the project's best aspects was that it included grading/leveling of the land, a task which is often today imposed upon farmers in order to reduce costs and as their part of the investment—but a task which is rarely done properly, if at all. RETAIL utilized land grading of smaller areas of 1,000 cubic meters to within three centimeters (dead level to within two centimeters would be better still by today's standards.).

In the RETAIL Project, sound water management at the farm level was possible from the outset due to carrying out the grading. The system was designed for downstream control, a very wise principle for both farmers and water economy. At the head of the tertiary canals, modular mask-type gates were put in place, just upstream from a duckbill weir in the secondary canal. In effect, the construction was "turn-key," a concept which today seems unpopular because even then it cost 4.5 million CFAF per hectare. The construction phase was largely carried out by private enterprise.

Several advanced technologies were in a short time made effective—transplanting, use of fertilizer, introduction of high-performing varieties of rice, animal traction, etc. A crop intensity of 1.25 was rapidly achieved with the 25 percent allotted to vegetable crops for women and youth during the off-season. Yields increased to six tons per hectare and family income increased dramatically.

The RETAIL Project seems to have worked very closely with farmers, many of whom were previously considered itinerants or nomads. The achievement of spectacular results was due to the attitude of the farmers and at the same time it created solidarity and enthusiasm among them. The project worked with a joint farmer-ON committee to integrate farmers into the maintenance system. The AV in this instance played an increasingly important role from the outset. By all accounts, the results were lasting and soon many of the techniques, notably transplanting, spread to other areas.

Environmental-Agricultural Issues

Excess water infiltrated into the soil has in some areas created a groundwater table at, or just below, the surface, whereas it was once at a depth of 45 meters or so. This causes "water logging" where there is virtual continued water saturation of the root zone. A very high water table causes some salinization and alkalization of irrigated lands where groundwater is drawn to the surface by capillary action and evaporated, leaving residual salts on or near the surface. Progressive salinizations of an irrigated perimeter can cause it to be abandoned eventually.

Salt accumulation in the root zone can occur in any irrigated area as even the best irrigation water contains some salt. The plant takes up the water by osmosis and leaves the salt. Salt can then concentrate in the root zone where it is detrimental to a plant as the salt ties up a portion of the soil water and makes it unavailable to the plant. The usual solution to salt accumulation is to flush the root zone with a quantity of water in excess to that actually needed by the plant for its development. Even though the flushing water is the same quality as the water from which the salt came from originally, the concentration in the irrigation water is much less than that of the salts built up in the root zone. The salts are then dissolved and forced downward below the root zone and eventually collected in a surface system of drainage which flows back into the river. The river becomes slightly more saline as a result.

In the case of rice, any salt buildup in the soil is diluted by the standing water which saturates the root zone. Therefore, it would seem that salinization poses no serious problem to rice production. However, it does pose a problem for the vegetable crops grown in the off-season. Then, only the water needed for growing the crop is applied. Flushing water can be attempted, but if the water table is already high, it can be difficult to flush the root zone. Furthermore, the root zone itself must not be saturated as the vegetable crop roots will grow down to the water level and no further. Unlike rice, these roots must "breathe." Localized high areas which are not flooded, but are used for crops other than rice, also pose a problem. The proximity of the groundwater to the surface facilitates drawing, and evaporating, soil moisture near the ground surface, thereby accumulating salts in the root zone where flushing is not an easy option.

The problems of alkalization are similar but differ in that excess alkalinity is characterized by breakdown in soil structure to the extent that soil porosity is affected. Whereas salinization is often visible as light colored "crust" on clods and furrow ridges within a field, alkaline "salts" are dark colored and not readily visible except as they result in unproductive areas where soil structure is detrimentally altered.

In the long term, irrigation drainage is equally important as the ability to apply water. In Africa, many early irrigation designers mistakenly underestimated the importance of drainage since groundwater tables were originally far below the surface. They used their limited funds for what was considered the more important task of applying water. In defense of the ON, the original system was conceived with cotton in mind as the major crop, not rice, which is a very heavy user of water and is now using nearly double the water actually needed to grow the crop.

The standing, stagnant water of the ON has taken a toll. The area is infested with mosquitoes. More than half the children between two and nine have malaria and some 80 percent of those aged 7 to 14 have schistosomiasis. Furthermore, water wells are generally polluted, pesticides collect in drainage canals, and the sanitary conditions around housing in Niono and elsewhere within the ON are deplorable.

2.1.3 Sélingué

A dam constructed southwest of Bamako on the Sankarani, a tributary of the Niger, between 1977 and 1981 permits irrigation in irrigable areas below the dam and in the general direction of the town of Kangaba. The dam also provides electricity to Bamako and Ségou. At the present time irrigation is limited to one 800-hectare perimeter, which was developed in 1984 and rehabilitated between 1992 and 2001. Landholders double crop rice, attaining average yields of 4.8 tons of paddy per hectare in the rainy season and 5.5 tons in the off-season. In the higher areas of the perimeter farmers grow maize in the off-season but get an average yield of only 1.5 tons per hectare. The Sélingué farmers basically consider rice as a cash crop since they prefer maize for food. As a result, 80 percent of the rice harvest is sold.

Sélingué, like Baguinéda and the ON, is endowed with a government agency, ODRS (*Office de développement rural de Sélingué*). ORDS created village associations to take charge of land distribution, having first established farmer selection criteria, which included minimum levels of labor and agricultural equipment availability. Attracted by the relatively low cost and secure supply of water supplied by gravity flow, there were a large number of applicants for the available irrigable land and as a result land parcels are only one-half hectare in size. Twenty percent of the landholders are not native to the area. Some of them are government officials and wealthy merchants who were able to obtain favorably located parcels.

While there is no competition for land between the rainfed crops traditionally grown in the area and rice on the irrigated perimeters of Sélingué, there is competition for labor, both family and wage labor. Absentee landholders who rely exclusively on hired farmhands exacerbate this situation.

Sélingué is much better off than either Baguinéda or the ON with respect to physical infrastructure because it is of more recent vintage and because the crucial role of the dam as supplier of electricity virtually ensures good monitoring and maintenance. ORDS charges a system user fee of 27,000 CFAF per hectare per season, part of which is used for the maintenance of the primary and secondary canals, several of which are lined. The AVs are responsible for maintenance of the tertiary and quaternary canals.

Four areas below the Séligué dam have been identified for future development. Two of them—Fanzan (605 ha) and Faraba-sombé (189 ha)—are within 15 kilometers of the dam and can be irrigated by gravity flow. A feeder canal from the dam will be required to supply them with water. The other two—Gouala-Kourouba (374 ha) and the Maninkoura plain (1,084 ha)—are some 45 kilometers away and would have to be irrigated by pump. The African Development Bank has conducted pre-feasibility studies of the four areas below the dam and is said to be committed to the funding of the development of the Maninkoura plain.

The Yanfolila Ouest plain (518 ha) some 80 kilometers above the dam at Sélingué is also proposed for development with partial water control by flooding and utilizing water from the higher water stages of the dam's storage reservoir.

If these areas are to be developed and the whole Sélingué zone is to attain its potential for the irrigated production of rice and other crops, several constraints will have to be lifted. These include:

- Inadequate capacity for farmer management of water control structures;
- Lack of farm equipment;
- Inadequate training of farmers in improved production techniques; and
- Illnesses provoked by the presence of large areas of standing water on the irrigated lands below the dam.

2.1.4 Strengths and Weaknesses of Large-scale Irrigation by Gravity

Advantages

- This system provides water security during both the rainy season and, to a certain extent, during the off-season, depending upon whether the source is a storage dam or a diversion dam.
- Cropping can be intensified using high-yielding varieties (HYVs) and high-input technical packages to take full advantage of the certain availability of water.
- The plant-water relationship can be managed more efficiently because of the higher potential for flexible and efficient delivery of water in quantities required at the time it is needed by the crop.
- Planting dates can partially be controlled.
- Mechanization can be used for land preparation and leveling.
- Higher and more certain returns make research, extension and even innovations like the semi-mechanization of transplanting more affordable.

- The creation of large-scale perimeters does away with traditional land tenure practices and their complex land use rights. In their place, the perimeters provide to landholders relatively small parcels with fully controlled access to water as well as to new production technologies. As a result, the land becomes an important factor of production and landholders have the opportunity to become productive entrepreneurs if they have some type of “ownership” of the land.

Disadvantages

- This system has the highest cost of development per hectare and it will be even higher if new standards are set for eliminating wasted water in order to expand in the future.
- Lack of a properly designed drainage system may contribute to a buildup of salts in the root zone and limit the yield potential of improved technical packages.
- Rapid weed growth intensifies weed problems and requires greater investment in labor and other inputs.
- Heavy demand for land on the large perimeters has led to a situation, typified by Baguinéda, where villagers living within the perimeter or in close proximity have no land because influential people from elsewhere have taken so much. As a result, these villagers tend to become farm workers for hire rather than the smallholders they traditionally have been.
- In instances where new settlement is required, the ON being the prime example, there is serious lack of social cohesion, still evident in the ON today, because diverse outside groups have been mingled in the settlements. Often the newcomers do not have the financial or technical capacity needed to farm under the conditions of the perimeters.
- The high cost of the system user fee, particularly in the ON, and the farmer’s need to purchase inputs on credit have led to very serious levels of farm debt, and as a consequence landholders have been obliged to cede portions of their land to pay it off. Some turn to leasing their land to raise cash to make payments.
- Women and children who are hired to transplant and weed, respectively, are very poorly paid. They are obliged to work very fast to earn even a modest amount, and the quality of their work suffers for it.
- The impact on poverty of large perimeters, however productive they appear, is questionable. While the ON produces almost half of the rice that is consumed in Mali and production has increased substantially in recent years, the poor economic condition of the population residing there does not indicate that income per capita has risen very much. The heavy pressure for land and the constantly declining size of the average family’s irrigated area is a factor in this equation.[7]

[7] In the ON, from over 9 hectares per family in 1975 to 2.4 hectares in 2000.

2.2 Controlled Flooding or Irrigation with Partial Water Control

Main gates – controlled flooding near Ségou

This system is an ancient one, mainly used in the central Delta of the Niger, downstream of Ségou and around Mopti. Attempts to partially control the flood of the Niger and its tributaries such as the Bani became more widespread as a response to the 1970s drought. The technique is an improvement over free flooding, and it does provide some protection against rice-eating fish and against the drowning of immature rice plants by floodwaters.

In general, the water level of a river rises to the point where the river overflows its banks and spills into the adjacent floodplain via natural channels. These channels serve to flood the plain in times of high water and drain the plain as the river water level drops. The higher the river water level, the more area is flooded on the plain.

With the system called *submersion contrôlée*, the floodwaters are forced to enter the plain through a gate-type structure, often equipped with wire mesh to keep rice-eating fish from the floodplain. The structure can be closed once the water on the plain is sufficient or should the river level begin to drop. The gate retains the water on the plain until near harvest time when the gate is opened to allow the water to drain back into the river.

This system can be quite simple, consisting of minimal gates, perhaps a short canal, and protective dikes to prevent entry of unwanted water and/or to contain water inside the perimeter. Smaller canals, dikes or bunds, even small gates may exist *within* the perimeter to divide off areas of differing elevation and better distribute water to them. The varieties of rice may be tailored to the various water depths expected. Though these may be improved varieties compared to traditional floating rice varieties, they are still low-yielding in general—about two tons per hectare maximum as compared to one-half ton per hectare for an uncontrolled floodplain and five to six tons per hectare for the HYVs used where better water control is possible.

The major difficulty of this system of irrigated rice production stems from the timing of seeding with respect to the arrival of the flood crest. Seeding is carried out utilizing rainfall for germination and early growth. If the rice plants are too small at the time the river crests sufficiently to bring water into the floodplain, the tiny plants may drown or not be able to grow rapidly enough to keep pace with the rising water. If the flood crest is too late, the plants may simply wilt and die for lack of water. Worst of all, of course, is the case where the river flow never achieves a crest high enough to actually flood the plain or reaches a level which will only flood a small portion of the plain. This is a condition which may occur one year out of four or five.

Even assuming that crop failure occurs one year in three, sensitivity studies for the cost of construction reveal that up to one million CFAF per hectare can be spent before exceeding the break-even cost. A reasonable criterion for site selection would be 100,000 to 200,000 CFAF per hectare. This would force the early selection of only the most favorable development sites, sites where development would result in the maximum benefits for the amount invested. The annual cost of maintenance is but five percent of the development cost.

Attempts are underway to transform perimeters with partial water control into full water control structures. The Sofara plain is being converted. In the case of Dagawomina (Mopti Cercle), a lower area has been transformed into fishponds and a higher area into total water control with the aid of diesel-powered pumps.

The DAD Project (*Développement agricole du delta*) of CARE Mali uses a dike very effectively to prevent floodwater from receding before rice has matured. The project has installed other structures—dikes to control the direction of the flood, canals and gates—but the cost of developing one hectare was extremely low at 15,000 CFAF. (See Section 2.2.3 below.)

2.2.1 *Office Riz Ségou*

What is now *Office riz Ségou* (ORS) was originally administered jointly with similar activities in Mopti and Sikasso. In the 1970s it became a separate entity, and in 1990 its name was changed from *Opération riz Ségou* when it was transformed into a public administrative establishment. At that point ORS ceased to manage its perimeters directly and responsibility for assignment of land parcels fell to farmer groups. Some 146 village associations representing 234 villages regrouped themselves into irrigated sector associations (*association de casiers*) for the purpose. Currently, 16,250 farm units with an average of eight individuals per unit cultivate a maximum of 34,076 hectares. They grow rice in the rainy season and a variety of other crops, including cassava, tomatoes and shallots, in the off-season. Demand for irrigated land is strong. There are some 3,000 farm families on a waiting list. Efforts by ORS to assist farmers with their rainfed crops (millet, maize and fonio) have not succeeded in reducing the pressure. As is true on the total control perimeters, there are a significant number of absentee landholders, and this fact is a source of frustration for those who cannot get access to irrigated land.

A low number of farmers (10 to 15 percent) actually use the recommended technical packages. There is the usual competition for the use of farm equipment and labor, both family and wage labor, during periods of simultaneous demand for them by rainfed and irrigated crops. From a sociological point of view it can be said that, unlike the case in the ON, there is social cohesion among the majority of farm families that work the ORS perimeters. They are not a collection of individuals each going his own way but instead form a social unit where certain values and rules of conduct are respected.

ORS estimates that more than half of its irrigated area—18,500 hectares—could be converted from controlled flooding to gravity irrigation. The convertible zone is dominated by the Markala dam: 15,446 hectares are located in the Dioro area, with its feeder canal on the Niger just upstream from Markala, and 3,000 hectares are in the Sosse and Sibila irrigated sections (see Map C), which can be fed from the ON's Macina canal throughout the year. ORS has done some preliminary soil studies for the Tien irrigated sector in the Dioro zone. The ON is interested in conversion of Sosse-Sibila. In July 2002 the Council of Ministers announced that it had ratified an agreement with the Islamic Development Bank for a 4.6 billion CFAF loan to finance an integrated rural development project in the Ségou Region. The project includes the construction of irrigation infrastructure in the ORS zone to supply the Farako, Tamani and Dioro perimeters.

2.2.2 *Office Riz Mopti*

The *Office riz Mopti* (ORM) is similar in function to ORS. It has 190 villages in its zone, which includes the Cercles of Mopti, Djenné and Ténenkou. There are 18,500 farm units cultivating 33,800 hectares, of which 30,000 are suitable for rice.

The farmer groups established in the ORM zone have been several:

- Rice producer committees (*comités de producteurs de riz* [CPR]),
- Village associations (*associations villageoises* [AV]),
- Irrigated section management committees (*comités de gestion des casiers* [CGC]), and
- Joint committees (*comités paritaires* [CP]).

The latter two have had more authority than their predecessors, and ORM has transferred to them a certain number of responsibilities.

Criteria for the distribution of irrigated parcels have favored male heads of household who live in proximity to ORM perimeters and have the necessary equipment and labor at their disposal. The criteria are a handicap for women, but women have become landholders nonetheless and in the case of the Bargondaga perimeter, 29 percent of the landholders are women. A significant number of parcels, usually larger ones, have been reserved for influential people, including government officials, merchants and marabouts. In the Mopti/Sévaré perimeter, 48 percent of the landholders fall into this group. These favored groups also get larger than average parcels. There is considerable recourse to hired labor by landholders in ORM areas. The use of selected seed and other improved practices is quite low.

The irrigated sections of ORM hinder the traditional practices of both herdsmen and fishermen. Rice now grows on land where cattle herds passed during their seasonal migrations, and cattle normally return from rainfed pasture in October and November when the rice crop is not yet mature. The creation of three separate irrigated sections for cattle has not eased the conflict very much since the forage crops grown there are meager and the sections are poorly situated. The conflict with fishermen arises over the fact that irrigated sections occupy areas where fish used to reproduce and mature as well as over the use of metal screens to keep out rice-eating fish.

The farmers in three irrigated sections (Sofara, Torokoro and Kouna) have received training in improved practices and are technically more competent than many others. Since the villages in the ORM area were founded long ago and the landholders working the irrigated sections are native to the region, there is a remarkable level of social cohesion and shared values.

2.2.3 The DAD Project in Djenné

The DAD Project (*Développement agricole du delta*) is being implemented by CARE/Mali as one component of a household standard of living activity funded by USAID. Started in 1997, DAD works with close to 7.000 households and has had a very positive impact on some 49,000 hectares of irrigated land under partial water control. DAD has sought to improve both the organizational and the technical aspects of producing cereal and forage crops. The project enhances the capacities of inter-village associations (AIVs) and their management committees. Technically, by improving the ways to control the entry and exit of floodwater from irrigated sections and by introducing higher yielding rice varieties and other improved practices, DAD has helped to raise yields, production and farmer incomes significantly.

DAD works with four AIVs that incorporate 86 villages: Pondori (59 villages), Djiguinè (3), Djonké (8) and Syn (16). The project works only with irrigated areas larger than 1,000 hectares involving more than one village. The communities play an important role in the construction of irrigation structures. In general assemblies of their inter-village associations they discuss the type and placement of structures before building them. It is interesting to note that when a World Bank mission and MAEP officials visited Djenné to discuss construction of a small dam on the Bani River, they learned that local people did not want it, saying that the small structures they were building under DAD were quite sufficient.

Traditional land tenure arrangements have been respected. While these often marginalize certain groups, such as women, there has nonetheless been a general lack of conflict over land tenure issues. The majority of labor on the irrigated sections is family labor, though there is recourse to wage labor and the introduction of improved techniques has increased labor requirements. There is some conflict between irrigation on the one hand and livestock and fisheries on the other, but there is clearly less of it than in the ORM zone. Fish are allowed to break out into the flooded plain at an earlier date, and the rules for cattle transhumance are traditional and well established. The training and monitoring provided by DAD have noticeably strengthened local capacity. This is true both for management of the AIV and for technical innovations like the introduction of seed multiplication by contract farmers. Social cohesion is strong. An obvious advantage of the DAD irrigated sections is that they do not upset traditional land tenure practices but rather formalize and reinforce local tendencies to associate and work together.

DAD personnel and village leaders were also able to initiate and use mechanisms designed to resolve conflicts among the various groups. A potentially very serious conflict in the village of Syn was successfully resolved after portions of a protective dike were destroyed by unhappy villagers.

Agronomic Aspects

The increase in rice production in the areas under project improvement since project start-up is remarkable: a reported percentage increase of 356 percent for the 2000-2001 crop over that of 1997. CARE Mali’s performance indicators show that 31,293 hectares out of total area 49,794 hectares have been brought under improved management. HYVs of rice were used on all of a 9,750-hectare area.

Much of this increase is due to an interaction of factors many of which can be traced to direct actions of the DAD Project. With project help, the AIVs:

- Identified appropriate locations for flood-control structures on traditional rice-growing floodplains;
- Organized and provided labor for construction of control structures;
- Managed the improved irrigation control structures; and
- Used an improved package of practices for intensification of rice production, including more efficient use of organic and mineral fertilizer as well as multiplication and distribution of rice HYVs.

Critical to a successful outcome with this system of water control is the DAD Project's close interaction with the AIVs, so that structures can be strategically located and properly managed by the associations.

In October 2002 it appeared that this year's results are going to be greatly affected by the lack of floodwater (low crest) available from the river. Much the project area was receiving only marginal water, and many seeded areas were not going to produce a crop. It would be useful to determine how much the improved control structures contributed to the stability of total production this year.

Distribution and multiplication of improved HYVs using selected farmer multipliers seems to have been a success, but was limited at its inception by lack of foundation seed available from the national agency for seed multiplication (SSN). The seed multiplication program resulted from a survey of rice producer associations that brought about a farmer request for three improved varieties—BH2, BG-90-2 and C74. Of these varieties, BG-90-2 appears to be the most adaptable to variations in water depth.

However, this variety appears to be losing some of its resistance to Pericularia as observed in Sélingué and will have to watched for further weakening of disease resistance. With future reviews of this project it will be important to document the success of farmer seed multiplication. This method of seed distribution has been criticized in some parts of the country because it has led to increasing varietal mixtures and other seed impurities. These preoccupations can be addressed with access to more resources for on-farm inspection and farmer investment in small-scale cleaning, seed treatment equipment as well as improved on-farm storage.

The DAD Project initiated two innovative forms of crop-related credit. The first was designed to ensure that women involved in rice marketing have sufficient working capital when it is needed. Women's savings and credit groups were organized and included training in record keeping and the calculation of interest payments as part of the repayment process. The second scheme provides credit to farmers using stored rice as collateral. Rice not needed for family consumption is purchased and put into storage. It serves as collateral for loans for family needs and the purchase of inputs. The stored rice is then sold at a higher price just before planting time and distribution of any profit, less any unpaid loans, is given to the participating farmers. Local financial institutions are looking into ways to use certain elements of the scheme in their systems.

2.2.4 Strengths and Weaknesses of Controlled Flooding

Advantages

- Low cost of the system permits irrigation development, which benefits a large number of people, increasing their family incomes.
- Increased control of the water level allows limited use of HYVs.
- Growing a local forage crop can be facilitated.
- System limits damage to crops from the extremes of flooding (e.g., drowning immature rice plants or too great a depth in the later stages of plant development),
- Early return of floodwaters back into the river can be prevented,
- From a sociological perspective, a strength of the system is the social cohesion of the population involved. People have not been brought in from outside the zone and resettled; thus they are not required to acclimate to new surroundings or to establish bonds with new neighbors. The villages that participate in partially controlled flooding schemes are long established with solid traditions. The population has created enough social capital to enable it to organize itself to confront new challenges.
- Assignment of landholdings by ORS and ORM *after* irrigation sections were developed has simplified land tenure. It has tended to put landholders on a more equal footing, where the main difference lies in the farm equipment and labor that each has available, rather than in ancient social distinctions.
- The size of parcels with controlled flooding is advantageous to families. It encourages the family cohesion that comes from working together.
- Greater contribution to poverty reduction than gravity or pump systems because the system assures a more equitable distribution of production. The system provides a form of greater social security. In the case of the DAD Project, for example, traditional social structures have not been disrupted and farmers have not been shunted aside; instead the traditional ways have been reinforced.

Disadvantages

- Uncertainty of adequate rainfall and floodwater at the right time is the major drawback of this type of low-cost improvement. The system depends on the unpredictable cresting of the river. Crop loss one year in five is almost certain and is possible one year in three.
- From a sociological perspective, the lower level of productivity means that families sometimes can not produce enough on the floodplains to meet their own needs. This leads to extensive farming, which can provoke conflict with other production systems, or even cause migration by some able-bodied family members.
- Financially able to borrow or rent land, well-to-do absentee landholders in effect can prevent needier families from gaining access to land.

2.3 Irrigated Village Perimeters (PIVs)

This system covers a spectrum of sub-systems. In all cases water is extracted from a river or watercourse by a pump or other device. These include fixed pumping stations with very large diesel engines that power pumps or Archimedes screws to lift water. Smaller perimeters utilize diesel-powered pumps (*motopompes*), either mobile or on floating rafts. Water is pumped into a holding basin that dominates the area to be irrigated, and a system of canals delivers water by gravity to individual parcels, controlled by gates of various sorts. With the exception of very large village perimeters in the Timbuktu Region, the village perimeters irrigated by pump action are relatively small, ranging from the tiniest at one or two hectares (PEIF), through small two to eight hectare perimeters (MIG) to perimeters from 15 to 30 hectares.

Canals may or may not be lined with concrete. Protection dikes may be present as well as access roads. The costs of developing and operating such perimeters are relatively high, mainly because of the cost of pump operation and repair. The cost of developing one hectare of a perimeter with concrete-lined canals and a diesel-powered pump can be as much as 3.7 million CFAF. Without canal lining the cost is less, but maintenance costs are higher because of the need to avoid water losses. Farmer participation in construction also reduces the cost.

Adequate pump repair facilities and the availability of qualified pump repair technicians are essential. Furthermore, even though the perimeters are much smaller than the large gravity systems, the water user groups and associations that farm them must have the capacity to manage the system efficiently.

After the 1984 drought, the irrigated village perimeter (*périmètre irrigué villageois* [PIV]) was devised as a relief effort to quickly give villages alongside a river the ability to feed themselves or at least some options for food. The construction of the PIV was very primitive, consisting mainly of a diesel-powered pump and a hastily dug basin into which the pump discharged. The villagers then dug trenches to lead the water pumped onto and within the fields immediately beside the river, fields which usually sloped gradually away from the river. The *groupe motopompe* was a gift (from donor relief funds) to the village, as were fuel and seeds.

The years since then can be characterized by efforts to establish the system as a viable means of irrigation, even one of “total water control.” The criteria for selection of a village and an irrigated site have become much better, even very well, defined. There has also been considerable progress in setting the standards for the study, design and construction of the perimeters.

2.3.1 Mopti Region

The small size of many village perimeters is a source of problems. There is often an element of social or economic exclusivity in the farm units that are chosen to participate from among those in the village or villages that may be interested. Favored units may well get larger or more favorably situated parcels. There are thus at least two sources of frustration that may undermine the cohesiveness of the operation—frustration on the part of those who have been excluded and on the part of those who have been included but were less favored in land allocation. Nonetheless, the challenge of developing and managing a PIV helps to build competence at the village level. The social cohesion of most villages involved in PIV irrigation enables them to face and overcome obstacles.

Conflicts between village perimeter farmers and herders are rather common and growing in frequency as the population expands. Perimeters sometimes occupy former pasture land or block cattle migration routes or simply attract cattle by the presence of hay or by their very greenness in an otherwise barren landscape during the off-season.

The EU-Sponsored VRES Project

From 1989 to 2002, the European Union (EU) funded the creation of 1,300 hectares of PIV in the Mopti Region and over the next five years will finance the creation of 1,200 hectares more. The project, known as VRES (*Valorisation des ressources en eau de surface*), involves small village perimeters in four sizes – 6, 15, 20 and 30 hectares. The cost of creating a perimeter varies from 800,000 to 1.2 million CFAF per hectare, including a diesel-powered pump which is purchased in two parts and assembled at Mopti. Initially, VRES provides the pump and funds for the purchase of fuel and inputs. From their first harvest, the farmers are asked to set aside and sell enough rice or other product to repay the amount of the subsidy.

Those who will farm the perimeter provide labor input for its development. Farmers are organized into producer associations, each drawn from seven to eight villages. The associations recruit their own extension agents and management advisors (*conseillers agricoles et en gestion*). Responsibility for managing the perimeter falls on a management committee, which is also responsible for training. Over time the farmers will pay for extension services. In 2002-2003 VRES pays 100 percent of the cost. However, the next year it will pay 75 percent and the farmers will pay 25 percent. The following year it will be 50-50.

The project provides selected seed from the National Seed Service via the research station at Niono and is establishing a program to train farmers to multiply seed. The average yield on the VRES perimeters is six tons per hectare, confirmed by research, according to the EU. Such is the success of the PIV that VRES wants to put in place a decentralized financial system that will be able to mobilize and invest the savings of PIV farmers. Apparently other farmers have been impressed enough to construct over 400 hectares of PIV without any help from VRES. VRES recommends a crop other than rice, such as horticultural crops, in the off-season but expected the farmers to be growing rice in 2001-2002.

It is noteworthy that there are VRES perimeters farmed entirely by women. On the 20- and 30-hectare perimeters there are social conflicts whereas the smaller six-hectare perimeters work well. Often they are cultivated by people who are all related. Perimeters of less than six hectares do not work because their smaller pumps are too fragile. Trying to extend a six-hectare perimeter to eight hectares does not work either, according to the EU, because it is beyond the capacity of the pump.

According to the former director of VRES, the weaknesses of its PIV system are the high cost of investment, heavy labor requirements and the necessity of relying on diesel-powered pumps. At the present time there is no reliable way of maintaining the pumps, despite the efforts of a garage in Sévaré to service them. The EU thinks that a new Spanish project on mechanization based in Sévaré gives some hope for the future.

2.3.2 Timbuktu Region

The PIV in Diré are similar to those in the Mopti Region, whereas the large perimeters of Koriomé, Daye and Amadja, which use the Archimedes auger powered by a diesel engine, are quite different. In both places, however, the plains which have been turned into irrigated perimeters had been considered the property of certain individuals. Once the perimeters had been developed, these individuals received favorable land rights allocations without respect to farmer selection criteria. Government officials and merchants also received land rights. The result is that there is a fairly high prevalence of absentee farming, either through hiring farm labor or through share-cropping (*metayage*). This phenomenon has resulted in widespread lack of observance of technical recommendations and in poor maintenance of the perimeters.

The large perimeters produce a single rice crop when there is ample water in the Niger. Yields average about five tons per hectare. In Diré 2,110 hectares are devoted to rice and an additional 520 hectares are used for flood-recession rice production. Farm unit parcels on all the perimeters tend to be about one-half hectare. Much labor is done by hand. The remoteness of the region means that it primarily provides food for local consumption.

Management of the perimeters is in the hands of various cooperatives and associations. It is evident, however, that absenteeism and social pressures have had a negative impact. The management committees are ineffective; system use charges are collected only intermittently; technical standards are not maintained; management capacity is lacking; and equipment is poorly maintained. An extreme example of inefficiency is the fact that a diesel-powered pump on the Amadja perimeter was recently inoperable for a month simply because it lacked an oil filter.

Access to Transport

Both the Timbuktu and Diré production areas have very limited road access. The area roads are undergoing improvement to assure more efficient dry season access. Boat transport is restricted to the few months that the river is high. Such items as agricultural inputs and fuel must be ordered months ahead and stored until needed if brought into the region by boat. Trucks, in spite of the very primitive road system, bring in most of these items. Rainy season access via boat transport on the Niger River is the most secure and cheapest means of shipping production out until the access roads are improved. However, COMANAV (*Compagnie Malienne de navigation*), the old parastatal that runs large vessels in the river trade, has a virtual monopoly.

Potential for Diversification

Apart from traditional irrigated rice production in the area, there is much scope for diversification of production if problems of transport and marketing can be resolved. The climate, particularly in the dry season during colder months, provides an ideal growing environment for many crops, notably wheat. There is also traditional and valuable cash crop production of spices such as cumin and anise which are marketed in Ghana and Niger. Land is available for an expansion of production, but the labor supply for it is questionable.

Wheat in Diré

Mali currently produces 9,000 tons of wheat in Diré. Three-quarters of this production is consumed locally and one-quarter is shipped by barge upstream to Bamako. For the last four years, a Canadian-financed project, PACCEM (*Projet d'appui à la commercialization des céréals au Mali*), has been working on the production of wheat in the area. The project supports research on wheat production and marketing of the grain produced. Though it did not intend to get involved in production per se, PACCEM has been obliged to do so.

One positive result is that yield has increased to three tons per hectare from an average of 1.8 to 2 tons. This is still well below potential, however. Similar production environments in Mexico, Pakistan and Bangladesh produce average yields of five to seven tons per hectare.

PACCEM found that perimeter development was a major constraint. The project provided diesel-powered pumps, paid for some land surveying and also paid for construction materials for canals. The first 10 diesel-powered pumps were distributed, but the last six have been sitting in a warehouse for three years because no one wants them, or at least wants to pay for them. One reason for this is that production with the pumps is barely profitable. The Canadian project director maintains that they are profitable but concedes that they are "not ideal" under the conditions found in Diré.

The Canadian International Development Agency (CIDA) has questioned whether it should continue working in wheat. The agency is concerned that the Malian government (OMGRM) appears to have no vision about what should be done in the wheat sub-sector. There is no conceptual document to show the way. The PACCEM project was supposed end in October 2002 but was extended to December 2002. CIDA, which has been holding discussions with the GRM on a second phase, is said to be willing to finance another five years for the Ségou component of its activity but not at Diré unless the GRM agrees to make a serious investment in wheat. In September 2002 it appeared that CIDA would continue for one more year in Diré but would then withdraw unless something happened.

The Canadian project director understands that wheat is a priority for the Ministry of Finance and that MAEP is seeking the means to increase wheat production so as to double output from the current 9,000 tons to 20,000 tons. This will entail new infrastructure for 3,000 to 3,500 hectares, along with a program to improve seed. DNAER plans to develop 10,000 hectares of irrigated wheat in Diré.

Current estimates of national consumption are 50,000 to 60,000 tons of wheat flour annually. Meeting this demand from domestic production would require 90,000 tons of wheat per year to be grown in Mali with the existing milling yield. It is estimated that with 10,000 additional hectares, national needs will be met. The SNDI proposed that 3,000 hectares be developed by 2002 and a total of 10,000 by 2005 from an area of approximately 100,000 hectares of land capable of growing wheat in the Timbuktu Region.

Before rushing into irrigation area development, however, it would be worthwhile to consider some of the factors that currently limit the intensification of wheat production. These include:

- Poor water management;
- Timing of rice harvest and preparation of wheat land for sowing creates conflict, thus preventing both from being grown successively on the same field;
- Poorly developed wheat production research strategy;
- Lack of timely land preparation techniques for wheat production following the rice crop;
- Need for improved wheat seeding techniques that promote uniform germination and correct plant density for optimum irrigated production;
- Need for advanced weed control techniques, mechanical and chemical;
- Need to introduce various aspects of mechanization, including harvesting and grain storage;
- Poor layout of some irrigation systems;
- Inappropriate selection of diesel-powered pumps (incorrect size pump for the area to be irrigated); and
- Current varieties of both durum and bread wheat are low yielding and are decades old. Newer wheat varieties are available which have stable, higher yields. These new varieties need to be selected and tested using improved germplasm from CIMMYT nurseries.

2.3.3 Strengths and Weaknesses of Irrigated Village Perimeters

Advantages

- This system can provide water security during both the rainy season and the off-season given that adequate water is available from the river in the off-season.
- Cropping can be intensified using HYVs and high-input technical packages to take full advantage of improved genetic potential and to validate the high cost of delivered water.
- The plant-water relationship can be managed more efficiently.
- Planting dates can partially be controlled.
- Mechanization can be used for land preparation and leveling.
- Higher returns make research, extension and even innovations like the semi-mechanization of transplanting more affordable.
- PIVs allow farm families to harvest rice and other food crops in areas and under circumstances that may offer few or no other options. The 2,100 farm families that work on the Timbuktu perimeters represent 14 percent of the population of the Cercle and have an opportunity to provide food not only for themselves but also for a significant number of neighbors.

Disadvantages

- Pumps: high cost of operation and maintenance, along with the unreliability of pump repair services.
- Heavy labor requirements.
- There may not be enough volume of water to leach salts away from the root zone of plants.
- Sharecropping and recourse to wage labor on PIVs create a situation where the rich get richer and the poor, unable to access land, become poorer.

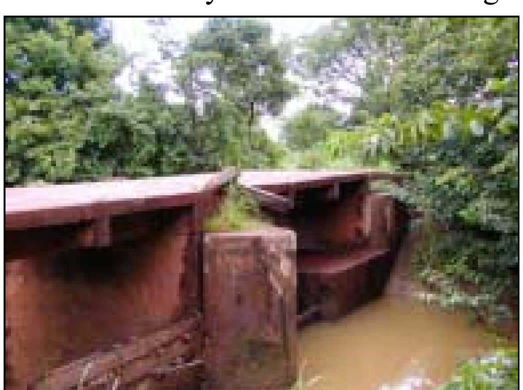
2.4 Irrigation of Small Valley Basins and Large Plains (*Bas-fonds*)

The irrigation system as developed for small inland valley basins (*bas-fonds)* is similar to that of *submersion contrôlée* discussed above. One major difference is that the water supply is derived from rainfall across a watershed which is naturally collected in a stream. As the stream flows toward the river, its water is blocked and partially retained in an area of depression or is partially diverted onto an adjacent plain. There may be a series of blocking and/or diverting structures that retain and utilize the stream water as it descends and flows toward the river. The fact that the watercourses end up in larger rivers facilitates drainage from the irrigated areas.

Even in years of lower rainfall (barring total drought) this system will reap the benefit of utilizing the water available on some part of the potential irrigated area. It is not perceived as being as high a risk as that of *submersion contrôlée* in that in bad rainfall years, the system still utilizes the limited rainfall on a restricted or reduced area.

This type of opportunistic irrigation is almost exclusively found in the areas of higher rainfall (700 to 1200 mm) in Mali-Sud. The area has important watersheds that funnel rainwater runoff onto large, flat plains and valley floors. Irrigated plains and *bas-fonds* are located in the upper valley of the Niger, in the Sikasso Region and to some extent in the Kayes Region, where the watersheds flow into the Senegal River or its tributaries.

It is noteworthy that women tend to grow rice and horticultural crops on undeveloped *bas-fonds*, which also provide dry season pasture and watering holes for cattle as well as fishing grounds. Often when a *bas-fond* has been developed with control structures, assuring off-season cultivation, men take over its exploitation. Conflicts then arise because women have been shunted aside and the other uses have been reduced.



40-year old road bridge used as a control structure for a bas-fonds plain

The cost of development is highly dependent upon the characteristics of the individual site and the degree of sophistication of water control one is able to justify. Of 33 *bas-fonds* completed in 2002 with funding from the AfDB, the average cost per hectare was 650,000 CFAF or $1,000. In general, the larger the area, the less the cost per hectare. Nothing over 15 hectares costs more than one million CFAF per hectare. However, for development of a plain like Kléla with a sophisticated system of efficient water control, the price could be as much as 2.7 million CFAF per hectare. Annual maintenance of these systems costs five to ten percent of the cost of initial development.

2.4.1 OHVN Zone

In the upper valley of the Niger in the 1960s there was a water control system to provide water from small streams to a number of plains, but it has deteriorated since then. In this zone, women now grow rice and horticultural crops on small *bas-fonds* of only one to three hectares. From 1978 to 1986 USAID was involved in a major agricultural development activity called *Opération haute vallée du Niger.* The successor agency is an *Office* (OHVN).

With its own funds OHVN has prepared a collection of pre-feasibility studies entitled "*Projet d'aménagement de bas-fonds et petites plaines en zone OHVN: requête de financement, mars 2002*." The studies propose small dams, structures to divert stream flow, drainage structures and others. This is a good source document with some 26 studies done on individual *bas-fonds* sites. Of these about 14 have been done, but 12 or so still remain without funding. One of them is the plain of Boucoumana (1600 ha), which the study team visited.

At Farabana in the OHVN zone there is an old 500-hectare perimeter that was developed by the North Koreans and then abandoned after a couple of years, largely because the canal system did not hold its water. A previous Minister of Rural Development wanted to rehabilitate the perimeter and commissioned studies. The process moved to the point of issuing a request for proposals, but a new Minister did not care to follow up and nothing materialized. The Rural Economy Institute (IER) has conducted a soil study of the perimeter.

2.4.2 Mali-Sud – the CMDT Zone

Bas-fonds, particularly small ones, are widely used in Mali-Sud. A study[8] of *bas-fonds* in the region conducted in 1996-1997 surveyed 221 women rice farmers[9] selected from a sample of twelve villages. Of four rice-production systems that it identified, the one that proved to be most profitable was one that was undeveloped, used neither selected seed nor mineral fertilizer but did use herbicides. The labor savings were such that a kilo of paddy cost only 43 CFAF to produce and returns to a person-day of family labor were 2,971 CFAF. In second place was a system that had been developed and used all the inputs. Two other systems using different combinations trailed.

In fact, the study found that rice cultivation on *bas-fonds* is more profitable than growing maize, millet/sorghum or cotton. Cotton came in last. Within a radius of 700 kilometers, rice produced

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8 Dimithè et al., *Bulletins de synthèse sur la riziculture de bas-fonds.*

9 The study notes that 88 percent of rice farmers on the *bas-fonds* are women, who have no access to credit. The male members of their households get credit from CMDT for their cotton crop but generally do not share it with women.

on *bas-fonds* in Mali-Sud was more competitive than rice from the Office du Niger. However, the study noted a number of problems. For example,

- The improved varieties being used have been developed for more arid conditions in the ON and hence produce less in Mali-Sud.
- Control structures, where used, need to be improved and can be improved with investments that ensure water delivery to the parcel level.
- Given the present level of water control, lack of labor for weeding is the largest constraint.
- Soil fertility is low.
- Quality of land preparation is poor.
- Plant disease and pest attacks are common.

At least four donors have been involved in promoting *bas-fonds* in the CMDT cotton zone – the European Development Fund (EDF), the Dutch, the World Bank and the AfDB. EDF funding began in the 1970s. The Dutch were the first to work with village labor to build structures. They worked in the Bougouni area with a CMDT team. The World Bank financed a second phase in Bougouni, using local consulting firms rather than CMDT. The AfDB began in 1993, also in the Bougouni area, and its activity continued until September 2002. The bank's projects use local contractors to build structures and require that beneficiaries pay 20 percent of the cost in cash.

Since 1990 CMDT has been developing small *bas-fonds* in its zone in accordance with GRM policy. There are now 273 *bas-fonds* covering 8,066 hectares that have been developed in the cotton zone with the financial and technical assistance of the cotton company. CMDT headquarters is the first to admit that the small *bas-fonds* have not delivered the results desired. As a general rule, mastery of the water supply has not been established and the *bas-fonds* are poorly managed by their committees. Technicians from CMDT and the regional extension services emphatically agree that physical development is not enough: improved practices, better seed, technical advice and monitoring are needed. Structures can deteriorate quickly if the beneficiaries do not know how to use them. In fact, there has been little or no technical assistance follow-up to train *bas-fonds* farmers in rice production techniques and provide them with management skills.

This situation is exacerbated by the withdrawal of CMDT from functions unrelated to cotton, now underway. CMDT's extension service responsibilities are supposed to be transferred to the regional offices of DNAER and DNAMR, but the agency budgets and staffing have not been augmented to prepare for it.

For example, on the Kléla plain 35 kilometers north of Sikasso, which covers almost 1,500 hectares, there used to be 14 CMDT staff present to advise farmers and help manage the system. In mid-September 2002 there was only one agent left, the perimeter head. He expected to hand over responsibility to the regional extension service (DRAMR) within a few days but realized that DRAMR did not have adequate staff and hence was unsure when it would happen.

Under the CMDT system, it was company staff rather than farmers who acted as irrigated section chiefs (*chefs de casier*) and who were supposed to pass requests for irrigation to the perimeter head, also a CMDT employee. The indications are that this system worked poorly, if at all.

Cultivation on small *bas-fonds* is by hand labor. The conflicting demands of farm households for labor to grow cotton, maize and millet during the rainy season render it difficult to devote adequate time to rice in the *bas-fonds* at the same time. Furthermore, productivity suffers from lack of selected rice seed and other inputs.

The picture is rather different for the larger plains in the CMDT zone. The regional extension services note that a number of plains have permanent watercourses and advocate focus on these areas. Two plains in particular are worth noting. The Kléla plain now has 1,100 hectares being irrigated by controlled submersion but an adjacent 381 hectares have already been converted to *maîtrise totale*, if somewhat inefficiently. The main plain of 1,100 hectares needs to be rehabilitated as at least one of its structures severely limits the irrigation of the lower portion of the plain. A second large plain near San, covering 400 hectares under controlled submersion and 800 hectares under *maîtrise totale*, is a crucial source of rice for the town. CMDT staff is convinced that when water supply is properly mastered on the large plains, good results will be forthcoming. They consider production on small *bas-fonds* to be strictly for supplemental rather than primary production, but they note that many *bas-fonds* that have never been developed produce rather well in their own fashion.

2.4.3 Kayes

The Manantali dam on the Bafing River, a tributary of the Senegal River, was completed in 1987. Thirty villages were displaced to make way for the dam and its reservoir. USAID played an instrumental role in the resettlement process. Construction of the dam created the possibility of irrigating 375,000 hectares in the three countries involved—Mali, Mauritania and Senegal. However, Mali had the potential to develop only 15,000 hectares.

To exploit this potential, Mali created a five-year project, PDIAM (*Projet de développement rural intégré en aval du barrage de Manatali*) that began functioning in January 2000. In addition to the GRM, four sources provide funding—the Saudi Development Fund, the Kuwait Fund, the Islamic Development Bank and the Organization of Petroleum Exporting Countries (OPEC). Ninety-five percent of the available funding goes to the development of infrastructure, but there are other components to the project as well. These include the provision of equipment and training in literacy and technical subjects.

PDIAM is developing two perimeters, one of 880 hectares for pump irrigation and another of 682 hectares. PDIAM also funded a study, which is being conducted by a Kuwaiti consulting firm, of the feasibility of creating additional perimeters between 60 and 600 hectares in size on an area that covers 2,500 hectares. There is no financing yet for the development of these perimeters, but funds for it are expected to be included in the second phase of PDIAM, beginning in 2005.

The project would like to create *bas-fonds* of 15 to 30 hectares as has been done in Mali-Sud. There is plenty of rainfall and hence seasonal watercourses in the southern part of the PDIAM zone. Keniéba gets good rainfall, and Faraba experiences a long rainy season from the end of April to the end of November, according to the PDIAM director. For villages that are located at some distance from the perimeters, PDIAM plans to provide structure for five small *bas-fonds* in 2003 and another five in 2004.

In fact, the project's zone in the Kayes Region is a difficult one for irrigation because the topography is uneven and the sites that could be developed are relatively small. As a result of the topography and the isolation of towns and villages within the region, the cost of creating an irrigated perimeter is extremely high, in excess of eight million CFAF per hectare.

2.4.4 Bandiagara

The Dogon plateau is a big producer of shallots, which are grown with the aid of water supplied by small hillside dams (*barrages collinaires*). According to a 1998 report on an agricultural extension project in the area—*Projet de vulgarisation agricole en pays Dogon* (PVAPD)—the plateau produces 20,000 to 30,000 tons of shallots annually. However, since the main market is Bamako, some 700 km distant, almost half of the fresh shallots used to be lost in transit. To overcome this handicap, a dried product called *echalote séchée en tranches* was developed and began to be promoted in 1990 as a direct substitute for fresh shallots. The plateau now supplies markets in Mopti as well as Bamako and according to the project report had more demand than it could satisfy.

2.4.5 Strengths and Weaknesses of *Bas-fonds*

Advantages

- *Bas-fonds* are often intensively cultivated when undeveloped, particularly when they are located in peri-urban areas. They can produce 50 tons of potatoes per hectare per year as well as horticultural crops for urban markets. They benefit women, young adult males and other groups that tend to be marginalized.
- When well designed, *bas-fonds* can attain excellent levels of water control.
- Carefully selected sites can be developed very economically.
- Some sites will be strategic with regard to empowerment of the disadvantaged of society and may be selected for development in spite of a higher cost. Even so, the cost should not prove to be excessive.

Disadvantages

- In the past, mastery of the water supply has not been established and *bas-fonds* poorly managed. Improved practices, better seed, technical advice and monitoring are needed.
- Land tenure problems, particularly conflicts over traditional uses for livestock and fisheries, can be serious and need to be realistically confronted and resolved, if possible, before development of a selected site is undertaken. At the least, additional effort and funds must be invested in the development of the local organizations that are capable of resolving such potential conflicts and managing the site over the long run.

Table 2.1. Donor-Funded Projects

Donor	Ongoing Projects	Comment on Projects	Future Plans
Canada (CIDA)	1. PACCEM (*Projet d'appui a la commercialization des cereals au Mali*), 1997-2002, has two components: a. Marketing rice and other cereals from the Office du Niger b. Supporting the production (and marketing) of wheat from Diré	a. This component has worked with USAID on marketing rice. The component ends on 31 October 2002 b. This component is in its fifth year. Perimeter development is a major constraint, so PACCEM has become involved in production. It has provided motor pumps and paid for land surveys and construction materials. A second set of pumps has found no takers. CIDA questions their viability in Dire and laments the lack of vision for the subsector.	a. CIDA has been discussing a second phase with the GRM and is willing to finance another five years. b. CIDA is prepared to fund only one more year in Dire unless the GRM agrees to make a serious investment in wheat. CIDA expects the GRM to issue a *Note Technique* setting forth its commitment to provide infrastructure for up to 3,500 more ha.
European Union	1. VRES 3 (*Valorisation des ressources en eau de surface*), Mopti Region 2. Office du Niger 3. Rice Database Network 4. Monitoring Maintenance of the ON Canal System	1. VRES promotes small village perimeters, 6 to 30 ha. From 1989 to 2002, the EU financed 1,300 PIV. VRES provides a pump and operating funds for first year; beneficiaries provide labor. NGOs provide technical assistance. 2. The EU is financing the rehabilitation of 1,200 ha on the Boky Were perimeter in the Macina zone. An RFP for the work will be issued in November. 3. The network will be housed at APCAM (*Assemblee permanent des chambers d'agriculture au Mali*). A study was being drafted by a French organization in Sept. 4. Project will create a database, establish present status of maintenance, examine problems, and determine how maintenance influences production. Project was supposed to start 9/1/02; it will be underway by the end of the year.	1. From 2002 to 2007, the EU will finance the creation of 1,200 additional PIV. 2. No plans for additional funding of the ON or other rural development activities in the upcoming 9th European Development Fund. 3. Implementation of the network. 4. Implementation of the monitoring project.

Donor	Ongoing Projects	Comment on Projects	Future Plans
France (AFD)	1. Office du Niger e. Support for research and development in the ON through a unit called URD/OC f. Support for service delivery centers in the ON	1. Past projects: a. Costes-Ongoiba Canal, 1979; b. RETAIL 1, 2 & 3, 1986-96(?); c. Rehabilitation of Points A & B, 1996; and d. Molodo sector rehabilitation, 1995-2002. [Total cost of a-d: 64.5 million euros] Rehabilitation of the Molodo perimeter (the primary canal and 1,430 ha) comes to an end on 31 Dec. 2002 after four years. Total cost: 15.2 million euros.	1. The AFD considers itself to be stymied. Before making any new commitment to the ON, France is looking for the GRM to produce a master plan (*schema directeur*) that will set forth long-term plans for the ON, including the role of the ON and the new local government units. The AFD seeks more transparency and effective irrigation management transfer to water user groups. The joint letter from donors to the Minister of Rural Development on 11 Feb. 2002 set forth France's concerns.
Germany	1. Mali Nord project in Diré and Goundam 2. Office du Niger Restructuring and Rehabilitation	 2. From 1988 to 1998, Germany provided 13.9 million euros in financial assistance to the ON. Germany did not supply any technical assistance. A second phase from 1998-2001 concentrated on the N'Debougou perimeter and provided 19.5 million euros.	 2. In 2001 the KfW signed a new agreement for a third phase that will extend past 2004. Germany's total commitment to the ON since 1988 will amount to 46 million euros.
Netherlands	1. Office du Niger b. ARPON 4 (Amélioration de la riziculture paysanne à l'Office du Niger) comes to an end in 2004	1. Past projects: a. Water Needs and Water Management projects (BEAU & GEAU), 1979-81; b. ARPON 1-3, 1982-97 (rehabilitation of 11,471 ha); c. Rehabilitation of Niono-Dogofiry road; [Total cost of a-c: 52.7 million euros] d. Agricultural Training Center, 1980-94; e. Agricultural Input Fund, 1982-99; f. Farm Equipment Assembly Workshop, 1982-97; g. Seed Farm, 1985-94; and h. Environmental study of the ON. The Dutch think that no one has gained from the parallel approaches to the ON that donors have taken in the past. They want to integrate the activities of ARPON 4 with those of PNIR and PASAOP.	1. No major projects are envisioned after 2003. There will be some small interventions outside of the ON, through NGOs such as the Near East Foundation. For the ON, the Dutch think that the ideal would be "basket funding," whereby donors put their funds into a common pot for implementation of a master plan for the ON.

Donor	Ongoing Projects	Comment on Projects	Future Plans
		They have withdrawn ARPON 4 technical assistance personnel from any responsibility for management. The Dutch believe that several key issues in the ON need to be addressed urgently. These include land tenure, environmental impacts and farmer organizations.	
World Bank	1. Office du Niger d. Rehabilitation of 6,000 ha in Sokolo and Kouroumari zones started in 2001.	1. Past projects: a. Technical assistance, 1979-83; b. Office du Niger 2, 1989-92; and c. Consolidation Office du Niger, 1989-97. [Total cost of a-c: $62.3 million]	1. Completion of rehabilitation of 6,000 ha.
	2. PNIR first phase, 2001-2005	2. One component of PNIR I is the installation of the private sector in the ON. Pilot activities are underway. A short-list of private investors has been developed. Ten have been selected to cultivate 50 ha each. Some should start in 2003. PNIR is selecting an enterprise to develop the primary infrastructure, which is the ON's responsibility.	2. Second and third phases of PNIR, 2006-2015.
	3. Creation of 1,000 ha of PIV in the northern Regions – Mopti, Gao, Timbuktu and Kidal	3. PIV to be developed along the Niger at the request of village groups. The VRES model will be used. Kidal will involve boreholes for irrigation.	3. Implementation of the PIV project.
	4. Private Irrigation Promotion Project (PPIP) in peri-urban areas	4. PPIP will cover about 1,000 ha around Kati, Koulikoro and other peri-urban sites. The project will aid landowners who are irrigating by diagnosing the weaknesses of their operations and helping to correct them. Implementation under the aegis of the Chambers of Agriculture.	4. The Bank has conducted an identification mission for a more ambitious future agricultural project. It will not focus on irrigation. Irrigation may be a part of the new project but not a major part.

3.0 Impact of the Irrigation Systems

In just the last decade the irrigation subsector has recorded major gains, thanks in part to a concerted effort to rehabilitate Mali's irrigation infrastructure, along with improved cultural practices, and in part to the 1994 devaluation of the CFA franc (CFAF).

Mali was virtually self-sufficient in rice in 2001-2002 after an exceptional harvest. The MDR's *Bilan de campagne* estimated paddy production at 840,000 metric tons, based on a sample survey of 2,500 farm units. Output represented a dramatic increase of 24 percent over the average harvest in the years 1996-2000 (see Appendix C.) Deducting 10 percent for losses and seed reserves and using an outturn of 69 percent, the MDR report estimated hulled rice availability at 522,000 tons. Although exports are impossible to know with precision because they consist largely of uncontrolled small quantities trucked into neighboring countries, the *Bilan* estimated total exports of 50,000 tons. This level comes close to matching imports of 70,000 tons. When other cereals were added, the country had a surplus of 66,000 tons of cereals in 2001-2002, compared to a deficit of 147,000 tons the previous year.

The tables in Appendix C show the remarkable increase in production of other irrigated crops such as potatoes, shallots, wheat and tomatoes over the past few years. The devaluation certainly had an impact on these crops, but even so the growth in the last few years is impressive.

Table 3.1. Increase in Production of Selected Crops

Crop	Prior Year	Production (T)	Production in 2001 (T)
Wheat	1990 to 1994	2,144 (average)	9,065
Potatoes	1997 & 1998	about 25,000	>100,000
Shallots/Onions	1990 & 1991	<10,000	>100,000
Tomatoes	1991 & 1992	<10,000	>60,000

SOURCE: Appendix C.

In light of recent gains, which have been supported by several donors, including USAID, the question is: where can additional USAID resources provide the most impact over the next 10 years in terms of production, productivity increases to ensure sustainability, and poverty reduction?

3.1 Total Water Control

The total, or almost total, water control systems give the highest and most reliable yields. They can also provide attractive returns on investment. It is therefore tempting to suggest that the bulk of USAID/Mali's resources be channeled into the Office du Niger, which is looking to expand by 120,000 hectares and to attract substantial private investment.

Financial Analysis

Financial analyses such as that of Aly Diallo[10] have shown that investment in expansion of irrigated rice production in the ON can be quite profitable. Diallo studied two sorts of development. In the first case he took as a model the M'Béwani perimeter, which was created in 1997 with assistance from the World Bank and the Netherlands and which had a novel feature for the ON—the beneficiaries played an important role in developing the perimeter. The cost per hectare (1.7 million CFAF) was much lower than it would have been if construction had been contracted out.

Some of Diallo's assumptions could be questioned (e.g., that 25 percent of the new perimeter would be double cropped and that a farm unit would cover 100 hectares.) Nonetheless, Diallo found very good internal rates of return (IRR) in this case. Even if the beneficiaries bore the *entire* cost of development, including primary irrigation structures, the IRR would be 12.1 percent.

Table 3.2. Internal Rates of Return, M'Béwani-Type Perimeter

ON Share of Cost	Paddy Price	IRR
0%	115 CFAF/kg	12.1%
30%	115 CFAF/kg	24.6%
45%	115 CFAF/kg	38.2%

Diallo's second case was one for large private investors (the so-called *grands privés*) who he assumes would have farming units of 1,000 hectares in the ON. As shown in the illustrative budget in Appendix C, the cost of development would be 3.7 million CFAF per hectare. Diallo assumed that half of the area would be used for rice, 300 hectares for potatoes, 100 hectares for bananas and 100 hectares for equipment and storage buildings. If the ON paid for the primary irrigation structures (45 percent of the total), as is the government's intention, while the investor covered the secondary and tertiary structures, the IRR at a paddy price of 115 CFAF per kilogram would be a very attractive 28.2 percent.

Even though the financial return appears promising, we believe that there are a number of underlying conditions in the ON which take some of the luster off the current impression that the Office du Niger is a reformed, modernized dynamo that has lately produced huge increases in output and yields. Indeed, the updated Rural Development Master Plan (SDDR) of 2000 did not hesitate to point out some of the ON's problems.[11] Concerns about the ON may be summarized as follows.

- Extremely high losses of water and hence very inefficient use of the resource;
- An alarming rise in the water table over time, causing soil degradation, i.e., increased salinity and alkalinity;
- Drainage problems causing negative environmental impacts;

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10 "*Les contraintes à l'investissement privé en l'Office du Niger*."
11 SDDR, p. 40.

- A low percentage of irrigated land (20 percent)[12] that is double cropped either in rice or in horticultural crops;
- An old, though half-rehabilitated, infrastructure that is costly to maintain and often considered to be "*trop sommaire;*"
- A high system user fee, fully half of which pays for various ON services and overhead and no part of which is actually based upon water used;
- A high level of farmer indebtedness leading to loss of land-use rights for some;
- Lack of farmer acceptance of responsibility for maintenance of the tertiary system, resulting in clogged canals, further water loss and inequitable water distribution for the "end of the line" users;
- Less than full empowerment of village associations as water-user associations;
- Poor social cohesion in the farm communities;
- The ON's unwillingness to cede control over land use rights and to be more transparent about its operations; and
- Concern among donors with regard to the future course of the ON (see Appendix A for details).

Many of these insufficiencies or negative aspects entail substantial hidden costs that, unless they are fully addressed and resolved, will only increase as time passes. Uncertainty about how and when the Office du Niger's problems will be overcome lessens the appeal of the unquestionably high and secure levels of production offered by investment in the ON. Nonetheless, continued USAID involvement of some kind as the donors work with the GRM to resolve the current difficulties is unquestionably desirable.

The study team considered several forms of involvement. If USAID were to invest in any kind of smallholder agriculture in the ON, the M'Béwani type of community perimeter described above would have some appeal because of the level of farmer participation in perimeter construction. On community perimeters the ON will clear the land and provide rough leveling (*grand planage*) as well as the secondary networks. (It is not known whether the ON will concrete-line the secondary canals.) The farmers take responsibility for the rest. However, whether the farmers have the resources to complete land leveling adequately, concrete-line any of the tertiary canals and install proper water control structures is dubious at best. If land leveling and canal lining are not accomplished, water wastage is likely to continue at an unacceptably high level.

Any new community perimeters would be located in the zones where some primary irrigation infrastructure already exists, as shown in Map C on page 19. ON staff responsible for perimeter development made it clear to the study team that expansion is to take place in these zones before moving to areas where no infrastructure exists.

12 6,465 ha in rice and 4,297 ha in a variety of other crops in 2001-2002 out of 54,404 ha cultivated in the 2001 rainy season.

The expansion zones are also open for exploitation by entrepreneurs. In this case the GRM agrees to fund fully functional primary networks but the entrepreneurs are responsible for the rest. One form of enterprise that holds appeal is the creation of private seed farms that can provide certified seed of high-yielding varieties to a wide array of smallholder farmers while bringing profit to the entrepreneur. If supported by USAID, such farms would be able to introduce the kind of water-use efficiency that must be widely adopted if the Office du Niger is to expand as much as it desires.

The perimeter development staff of ON suggested another principle – the upgrading of areas under controlled flooding that have an assured source of water, which would allow them to be converted to total water control. These areas are supervised by ORS, but have their water source either immediately upstream of the dam at Markala or from the Macina Canal in the ON. The areas considered were the Dioro complex on the southern bank of the Niger River and Sosse-Sibila between the Macina Canal and the northern bank. The study team visited the villages in the Tien area of the Dioro complex and examined the area of the Tien plain presently irrigated by controlled flooding. The team was very impressed by the industry of the people, their level of achievement with respect to agricultural technology and with the potential of the Tien plain as well.

The study team concluded that with a number of issues between the ON and the donors awaiting resolution, the best approach to the Office du Niger at present is for USAID to continue collaboration with other donors to resolve these issues while preparing components for a large-scale gravity irrigation activity. In Section 4 we recommend:

- Financial support for the construction of private seed farms that can pioneer a high standard of water-use efficiency;

- Conversion of controlled flooding land to total water control, also with a high level of water-use efficiency; and

- A rehabilitation program to empower small farmers in the Office du Niger through technical training and capacity building for truly effective water-user associations.

The contents of these components are described in Section 4.

3.2 Controlled Submersion or Flooding

The primary advantage of this traditional system, as compared to uncontrolled flooding (*submersion libre*), is improved water-level control during critical periods of plant development. The system's ability to assure a reliable crop is ultimately limited by the amount and timing of arrival of the flood crest as well as by the amount and timing of local rainfall that allows the crop to germinate and grow until floodwaters arrive. It is estimated that over a period of five years, one crop should be expected to be exceptionally good, one might be considered fairly good, one may be average, one somewhat poor and one year's crop a complete failure. With this system there is little possible diversification away from rice. The local forage crop (*bourgou*) is the only other crop currently grown under controlled flooding conditions.

The use of motor pumps to provide supplemental irrigation to assure rice emergence until flooding from the river is available has proven uneconomic when tried in the Mopti Region, largely because of the high pumping cost and the large quantities of water required. It has seen some limited success when small portable pumps are used on lands immediately adjacent to the riverbank.

The DAD Project (*Développement agricole du delta*) being implemented by CARE Mali has demonstrated ways in which productivity can be enhanced and risk reduced. DAD has introduced improved technology into the controlled flooding system. Intensification of rice production under improved water control has resulted in increases in yield from less than 600 kilograms per hectare to more than two tons per hectare. This increase resulted from careful location of control structures, introduction of new, more appropriate varieties, better village organization and technical assistance. The location and subsequent management of the control structures resulted from a well-planed hydraulic study in consultation with the villagers that maintain and operate the improved control system.

The DAD-type system would be even more effective with the addition to the technical package of simple grain storage facilities. This would allow the farmers to keep a part of the grain produced in good years to be consumed or sold during the inevitable bad year each three to five years. Even if one year in three produces a very poor crop, there should still be ample opportunity to put aside part of the crop in the better years to be able to get through the bad year.

Another possible improvement within a DAD-type perimeter would involve more precise knowledge of the land contours. The use of a contour map of the area would make it easier to locate the needed protection dikes more precisely. Use of a contour map would also enable project leaders to divide the entire area into different levels through the use of internal bunds around areas of nearly equal elevation. Additional ditches would convey water to the various levels. This would seem to be a natural "refinement" of the overall water control already in place or to be put in place during future development.

Compared to total-control systems, controlled flooding (even the improved DAD-type system) is clearly less productive on a per-hectare basis, with yields just above two tons rather than exceeding six, and considerably riskier. As mentioned earlier, the wide annual fluctuations in annual rice output from the Mopti Region, where controlled and uncontrolled flooding predominate, compare unfavorably with the steady increases in the Ségou Region, home of the Office du Niger.

However, when viewed from the twin perspectives of return on investment and ability to generate increased production rapidly, the improved DAD-type system is quite attractive. From 2000 to 2002 paddy production in the DAD zone around Djenné increased by an average of 55,840 tons per year[13], after an investment of less than one million dollars in infrastructure. A similar increase from one of the large total-control gravity systems would cost a large multiple of that amount. In the Office du Niger, for example, if one assumes average annual paddy output to

[13] In 2000 incremental production above the 1997 baseline was 97,840 tons; in 2001 it was 69,678 tons; and in 2002 there was inadequate flooding and the crop failed. The three-year average was thus 55,839 tons.

be seven tons per hectare—including 10 percent of the area double cropped in rice—it would take 8,000 newly developed hectares to produce 56,000 additional tons of paddy per year. Developing this additional area would require an investment of no less than 13.6 billion CFAF ($22 million) if community perimeters were built. The cost would be about 30 billion CFAF ($48 million) if contractors were involved. Furthermore, DAD-type infrastructure could be installed much more quickly than a large total-control system could be expanded.

In essence, investment in DAD-type controlled flooding can produce more rice per dollar invested, even under the pessimistic assumption of one crop failure every three years, than the same amount invested in expensive total-control perimeters with high yields assured each year. Financial analysis by the study team shows that conversion of an area from rice cultivation with uncontrolled flooding to a DAD-type controlled flooding system produces a very attractive IRR. Investment of only 156,000 CFAF ($250) per hectare,[14] resulting in an increase in annual yield of two tons per hectare, produces a stream a benefits over 20 years that give an IRR of 43 percent (see Appendix C). This rate assumes one crop failure every three years. The average annual increase will be 1.3 tons per year—two harvests averaging an increase of two tons and one harvest with none.

Controlled flooding with the DAD model has social and environmental as well as economic advantages not to be underestimated. The social cohesion is greater than with high-investment total control systems because the system is built on existing villages and their social structures. There has been virtually no settlement from outside and no social upheaval instigated. Those who farm the land tend to be people with use rights rather than farm laborers working for an influential absentee. The DAD-type system, which is labor–intensive and requires few purchased inputs, has an impact on a large number of people, including the poorest. Environmentally, the system has no major negative impacts and is positive in the sense that it maintains the water table at a higher level and produces increased biomass.

One big advantage is that the beneficiaries can, with ease, be heavily involved in the planning, creation and management of water control structures. This reduces costs and helps assure the good management and durability of the system. Proper planning and development can pay big dividends in increasing output and maximizing the efficient use of water.

3.3 Irrigated Village Perimeters

With land available in the north and water in the Niger, the PIV system offers the potential for meeting food needs in the region and even for producing wheat for the rest of the country, not to mention spices for export. However, a poor transportation network is a great hindrance, and it is not at all certain that there is enough labor to support any significant expansion from what is already there. For five years the Canadians (CIDA) have been struggling to get more wheat to market out of perimeters at Diré, but they are now discouraged by the government’s lack of vision for wheat, despite the GRM’s assertion that wheat production is a priority.

[14] In fact, the DAD Project’s *actual* investment was so low—an average of only 15,000 CFAF or $24 per hectare—that the cost of it was recovered in the first year. Assuming that investment over a large area would require construction of more protection dikes and hence that per hectare costs would be higher, the recommendation in Section 4.2 is based on 156,000 CFAF per hectare.

In CIDA's eyes, irrigating a wheat crop with diesel-powered pumps is financially profitable, if barely so. Yet even if farmers are producing more wheat, they show little interest in taking on the financial burden of a pump. On the marketing side they are faced with a parastatal monopoly on river transport. Shipment of wheat to Bamako by water is 30 percent cheaper and much more reliable than truck transport but is available only a few months of the year. Even if shipping were not a problem, the only buyer of the grain is the *Grands moulins* in the capital, and the miller is able to drive a hard bargain on price. Whether in these circumstances CIDA will continue to support wheat production and marketing beyond 2003 has been an open question.

In the Mopti Region the European Union's VRES project provides promising results. In fact, the World Bank intends to use the VRES model to create 1,000 hectares of PIV in the four northern regions—Mopti, Gao, Timbuktu and Kidal. Kidal will involve boreholes. In the other regions the PIV will be developed along the Niger at sites where villages express the desire to become involved. In addition to providing full water control, the VRES model has several attractive features. Farmers participate in the construction of their perimeters, choose their own extension agents, form a committee to manage the perimeter, and repay the first year's operating costs. Yet the model has drawbacks. It requires very heavy labor input, for example, and it is dependent on the smooth functioning of expensive-to-operate diesel-powered pumps. To date there is no reliable system for maintaining these pumps, which are proliferating as VRES distributes more and more, soon to be imitated by the World Bank project.

It is true that the PIV produce an attractive IRR of 28 percent (see Appendix C). Nonetheless, with two major donors involved in replicating PIV throughout the north, there may be little appeal for USAID in the idea of arriving late on the scene and essentially imitating them. Furthermore, despite optimism at DNAER that a garage in Sevaré is on the way to solving the pump maintenance problem, the former VRES director who now supervises the project from the EU's Bamako office is considerably less confident, hoping only that a new project funded by Spain will have an impact on the maintenance issue. He also ventures that when the last phase of VRES is completed in 2007 and the World Bank project winds down, few attractive sites for PIVs will be available in the Mopti Region or even further north.

3.4 *Bas-Fonds*

In small, inland valley basins and on the larger plains of Mali-Sud, there are numerous opportunities to build simple water retention structures that increase productivity and the area under cultivation, using the *bas-fonds* type of irrigation development. The *bas-fonds* system presents many of the same advantages as controlled flooding but with somewhat less risk. The advantages include the social grounding of the system in established villages, the potential for improving production at relatively modest cost, and a substantial impact on poverty. The system is less risky because it is dependent on rainfall in a well-watered area and not on the arrival of a river's flood crest.

It is a traditional system that, in its undeveloped state, offers opportunities to women since it tends to be neglected by men and thus allows their womenfolk to grow rice or horticultural crops for income. Indeed, in many places undeveloped *bas-fonds* appear to perform very well from several points of view—output, women's income and harmony with other production systems (rainfed agriculture, livestock and fisheries). In many cases, they would best be left undisturbed.

As mentioned in Section 2.4, developing irrigation structures for *bas-fonds* and the larger plains in southern Mali involves widely varying characteristics of individual sites and very different levels of sophistication of control structures. What is absolutely crucial for all of them is that the structures be the right ones and that they be properly placed. The study team visited one site where they had been misplaced in relation to the stream. The villagers advised that if they had been consulted, they would not have recommended the site that was chosen. This points to the need for participation of the beneficiary villages in the selection and design of sites.

Plains can start with partial water control and later be converted in whole, or more likely in part, to total control. This has been the case with the Kléla plain, which the study team visited. In moving to total control it is important to keep costs down while establishing conditions for attaining much higher yields. If the plain can be endowed with water-retention structures that would permit a second crop on 25 percent of the area or more, its viability will be enhanced considerably. Cultivation of high-value horticultural crops will greatly add to profitability.

The configuration and size of each plain will be different and will have an appreciable impact on both the cost of development and possibly on yields. In any case, there is every indication that carefully selected sites of sufficient size can provide the full benefits of the *bas-fonds* system provided that high-quality training and organizational work accompany development. This kind of follow-up was not evident in earlier efforts.

The next section provides detailed recommendations for a USAID/Mali program in irrigated agriculture.

Table 3.3. A System Comparison

System	Risk	Productivity	Crop Diversification	Gender	Social Factors
Total Water Control (Office du Niger)	Low: water supply is assured, except possibly in the event of severe drought.	High yields (6T/ha average) but high cost of development (estimates vary from 3.7 million CFAF/ha [A. Diallo] to 7.7 million for system with cement-lined canals; Poor use of available water: over 50% of water is lost en route to tertiary canals; Mechanization can be used and planting dates controlled.	Irrigated *casier* area with vegetable crops in the off-season has not exceeded 7.5% (7.5% in 1998/1999 and 2001/2002).	Women are principal producers of vegetable crops in the off-season; Teams of women transplant, weed and winnow rice, but they are informally organized and badly paid.	Lack of social cohesion; Widespread use of underage children as field workers; Prevalence of malaria & schistosomiasis; Water pollution and poor sanitary conditions; Vegetable production by women has some impact on poverty but much of what they earn goes to reimburse credit for inputs.
Total Water Control (Sélingué)	Very low: water supply is assured by retention reservoir or dam.	About 80% of the area produces two rice crops—in the rainy season the average yield is about 4.5 T/ha since work on dryland crops often delays planting; the off-season yield is better (about 5.5 T/ha).	Some vegetable production but mostly around the margins in the non-irrigated field and perimeter border area.		Absentee landholders; Illnesses provoked by large areas of standing water.
Irrigated Village Perimeters (PIV)	Low: principal risk factor is the pumps; Pump maintenance not reliable.	High yields (6 T/ha on VRES perimeters) but high development costs (3.7 million CFAF/ha) AND highest operating costs because of pumps; System is labor intensive.	Wheat is produced in Diré in the cool season; The same land is generally not used for both rice and wheat because of the overlap in the growing seasons.	Some VRES perimeters are farmed entirely by women	Active farmer participation in construction and management of VRES perimeters; Sharecropping and recourse to wage labor on larger PIVs impoverish landless poor.
Controlled Flooding	High: one crop failure every three to five years.	Low (500-600 kg/ha) in traditional system but very low development cost (from 156,000 CFAF/ha [DAD-type] to 700,000); Improved system (DAD) gets moderate yields of 2 T/ha; DAD system is low-input and labor intensive.	A local forage crop (*bourgou*) is only diversification from rice; *Bourgou* production has significantly increased under the DAD project because of better water retention on the plains.	Land allocation criteria favor men in ORM zone but women still become landholders; In the ORS zone women's groups cultivate parcels but they are not the neediest;	System takes existing technology (which can be improved) and social structure and builds on them – this is its strength; More equitable distribution of production than gravity or pump systems;

System	Risk	Productivity	Crop Diversification	Gender	Social Factors
				In the ORS zone women have successfully established processing enterprises.	The DAD system has a positive impact on a large number of people, including the poorest; Minimal social and environmental disturbance.
Small valley basin *bas-fonds*	Low: when well-designed, *bas-fonds* can attain excellent water control	Low yields (up to 1 T/ha) but costs of development can be as little as 300,000 CFAF/ha. Good control structures can double yields to moderate level of 2 T/ha or more.	Good opportunities for vegetable production on about 10% of rice area, largely depending on having water flow for a few months and on water stored in the soil profile after rice.	Undeveloped *bas-fonds* are usually farmed by women	Social grounding in established villages; Land use conflicts can be serious; Vegetable production by women in CMDT and OHVN zones has some impact on poverty but much of what they earn goes to reimburse credit for inputs.
Large plain *bas-fonds*	Medium to low: seasonal water courses are rather reliable; Possibility of water retention for off-season production.	When properly developed, plains can increase yields from 1.5 T/ha to 5 T/ha. Cost of development moderate at 2.6 million CFAF/ha.	If structures allow for water retention, double cropping is possible; Good opportunities for vegetable production.		Social grounding in established villages.

4.0 Study Team Recommendations

As a result of comparison of the major irrigation systems in Mali the study team proposes investment in four different systems. USAID/Mali should invest in all four of these options, each of which has its particular advantage. If the illustrative program suggested below is too ambitious, we recommend that USAID/Mali cut back proportionally on each of the options. In addition to investment in specific systems, the study team suggests three kinds of activity that either support the irrigation subsector generally (i.e., availability of improved seed and research on irrigation technology) or contribute to the development of the human potential in the Office du Niger.

Summary of Conclusions

Any discussion of irrigated agriculture in Mali usually begins and eventually ends with the Office du Niger because the ON has the potential for producing very large quantities of rice with less risk than other agricultural activities in the country. If Mali is to satisfy a growing population's increasing demand for rice and still have a significant quantity for export, the ON must play a significant role. Recognizing this, the GRM and several of its development partners (donors) have over the last two decades devoted huge sums to improving the ON's performance, and in many ways they have succeeded. However, as explained in Section 3.1, there are circumstances which cloud the future somewhat, circumstances that, for the moment at least, have given the major donors pause.

The donors are looking to the development of an ON master plan (*schéma directeur*) as a way to resolve their principal concerns and put the future evolution of the Office du Niger on the right track. In January 2003 the donors are expected to meet to elaborate terms of reference for the next stage of master plan development. There have been recent tremors over consultants' reports, but these seem to have been overcome, as described in Appendix A. The study team believes USAID/Mali should move cautiously, in concert with the other donors, until the outstanding issues are resolved and for the time being limit involvement in the Office du Niger to what is recommended here.

Investment in Irrigation Systems

- The team's recommendations with regard to irrigation systems are based on two ideas. First, in areas where water can be fully controlled, Mali's primary goal should be mastery of efficient water management on existing perimeters as a prelude to expansion rather than continued expansion of inefficient systems. This will entail concrete-lined canals in many instances, better land leveling, the use of gates that accurately measure water flow, payment for water actually used, and last but not least, empowerment of farmers to operate and manage their part of the system. Because efficient water management will have external

Lined main canal conserves precious water benefits—allowing the cultivation of more area than would be the case under current conditions—investment in new, efficient perimeters should be contemplated up to the point where it is close to a break-even proposition. Second, in areas where water can be only partially controlled, investment should be directed into the least costly and most productive structures first so as to exercise greater control, even if limited, over the available water on as many hectares as possible with a minimum of investment.

- The study team has based recommendations for investment in irrigation systems on the information obtained and impressions drawn from short visits to a variety of irrigation sites. The team did not have access to any feasibility studies for site development or to construction details. Given the broad scope of the study, the team could make no detailed analysis of the engineering requirements for specific sites. Implementing some of the recommendations in this section will require further studies to identify exact sites and more accurately specify costs and benefits.

- That being said, possible USAID interventions in irrigation systems can be ranked in order from lowest to highest cost of investment per metric ton of rice produced. Table 4.5 on page 67 provides details. This ranking is also in order from the highest to the lowest internal rate of return (see Appendix C). It is strictly financial and does not take into account the other benefits and advantages of each system, as expressed in Table 3.3 and elsewhere in this report.

1. **Conversion from uncontrolled to controlled flooding following the DAD model**. Even when the flood crest of the Niger is at a record-low level, a vast area of some 800,000 hectares in the central delta is the recipient of uncontrolled flooding. A sizeable portion of this area, up to 100,000 hectares, could be converted at very little expense to an improved controlled flooding system over the course of 10 years. At an average cost of \$250 (156,000 CFAF)[15] per hectare, paddy yields can quadruple within a year to two tons per hectare and later reach 2.5 tons. An increase of this magnitude requires correct management of control structures and new rice varieties, but the USAID-funded DAD Project has shown that a well-managed activity can achieve excellent results. A large number of farm families, including the poorest, will benefit, and women's incomes will rise from processing and marketing increased output. As discussed in Section 3.2, this kind of intervention can produce very large increments of rice production in a short time and with far less investment per ton than any other system. USAID is the one donor supporting this system. See Section 4.2 for more detail.

2. **Development of small valley basins (*bas-fonds*) in the south, using simple water-control technology**. Women can derive good benefits from the expansion of well-designed *bas-fonds* provided their farming rights are respected. Over a period of ten years, 9,000 hectares could be developed by USAID, increasing yield by over two tons of paddy per hectare. The vegetable production from these same areas often equals or exceeds the value of the rice produced. The sites need to be carefully chosen and irrigation structures properly sited. It will also be important to accompany development

[15] An exchange rate of 625 CFAF = \$1 is used in this report.

not only with technical advice but also with assistance to enable local groups to resolve conflicts over the use of common resources.

3. **Development of larger plains in the south**. A series of large, flat plains stretching from San to Kangaba, are irrigated using stream flow from the uplands The study team visited three plains that hold interesting potential for future development. Each site is unique, and hence it is difficult to generalize on the type of water control structures that will be required for larger plains. Over 3,000 hectares could be developed in a ten-year period at an average cost of $4,250 (2.7 million CFAF) per hectare. Yields can increase by at least three tons per hectare in the rainy season and viability can be assured with water-retention structures that allow double cropping of 25 to 50 percent of the irrigated area. See Section 4.3.

4. **Conversion from controlled flooding to total water control when the water source is assured**. Large, total-control systems are an important guarantor of a secure rice supply. Future expansion of the Office du Niger is a necessity, but it will be limited unless there is much less leakage of water from the system. By assisting in conversion to total control with efficient water management, USAID will create new irrigated sections that could serve as a model for future development work in the ON. The Dioro perimeter, which is presently under the jurisdiction of Office Riz Ségou and is located just outside the ON, has an assured source of water. In the space of 10 years, 2,250 hectares out of 15,446 hectares on the perimeter could be converted through USAID's support into a gravity delivery system with downstream control that assures efficient water management at the on-farm level. Increased yields can amount to four or five tons of paddy per hectare. Section 4.1 provides more detail.

- The team considered other options, notably (a) irrigated village perimeters (PIV) in the Mopti Region and the north and (b) areas benefiting from the Manantali and Sélingué dams, but concluded that these are less compelling. Other donors have a long head start and well-funded activities in most of these locations. See Sections 2.4.3, Section 3.3 and Table 2.1 for details.

Supporting Expansion of Malian Irrigation

- Since future investments in irrigation will depend on a responsive seed multiplication system with cost-effective production, a systematic review of the existing seed multiplication institutions should be carried out immediately. USAID/Mali should facilitate the development of mid- to large-scale private sector seed farms in the Office du Niger. This will place USAID/Mali at the forefront of the effort to induce substantial private investment in the ON while at the same time ensuring there will be tangible benefits to innumerable smallholder rice farmers around the country. This could be done under the PNIR program of providing incentives for private sector investment in the ON.

- In order to improve the productivity of rice farmers in the ON, USAID should sponsor activities that empower water-user associations and train their members to capably operate and maintain their irrigation systems. Promoting savings and loan programs and improved health and sanitary facilities in synergy with USAID activities in these sectors would contribute to the well-being of farm families in the ON, also enhancing their productivity.

- There is a low level of applied research on improved irrigation technology in Mali. Farmers and policymakers will increasingly require access to data on water use, improved methods of irrigation, and water management. A regional research and training center in Mali focusing on gravity systems delivering water via elaborate canal networks would serve the needs, not only of Mali but also of Senegal, Guinea and even The Gambia. The existing Burkina Faso irrigation center could then be relied upon to provide training in small *bas-fonds* and other water-harvesting systems. USAID has played a role in the establishment of centers for irrigation research in Asia. See Section 4.4 for details on these three recommendations for supporting the expansion of Malian irrigation.

To summarize, the study team recommends the following irrigation-related investments to USAID/Mali:

- Conversion of a controlled flooding site to total control;
- Continued development of DAD-type controlled flooding sites;
- Development of *bas-fonds*, both small valley basins and large plains; and
- Participation in selected support actions to strengthen the irrigation sector.

4.1 Conversion of a Site with an Assured Water Source from Controlled Flooding to "Total Control"

After conversations with both the Office du Niger and Office Riz Ségou the study team visited the Dioro perimeter (about 15,000 ha) and in particular the Tien irrigated section *(casier)*. The Dioro perimeter is presently supervised by ORS and irrigated by controlled flooding. Both ORS and ON wish to upgrade this area to "total control" or *maîtrise totale* since its water source is very reliable. Entry to its feeder canal is located just upstream of the Markala diversion dam. This perimeter presented the following advantages:

Team discusses controlled flooding with villagers

- This irrigated section is not presently part of the ON and does not have the negative aspects associated with farmer/ON relationships. It presents an opportunity to explore structuring the relationships between land, water, and human resources for a new beginning.
- A group of established villages vigorously exploit both dry and rainy season cropping systems of rice, melons, maize, sorghum and millet.
- There are well-observed traditional rights of access to land for rice cultivation on the areas under controlled flooding.

- There is good all-weather access to transport and markets both nationally and regionally by reason of proximity to Ségou.
- Farmers are well equipped and experienced in the use of animal traction for land preparation.
- Apparent levels of farm income would allow some farmer participation in costs of development.
- The plain can be developed in phases with the possibility of beginning with a small pilot area to demonstrate the effects of improved on-farm water management technology including canal-lining, level basins with drainage systems and measured water consumption.

4.1.1 Approximate Cost of Suggested Development

To obtain an accurate estimate for the cost of upgrading selected portions of the Dioro perimeter, detailed knowledge of what is already there and usable is needed as well as more detail concerning what is possible to achieve in each section of the large perimeter. With regard to the cost of upgrading sections from controlled flooding to total water control, two approaches are possible.

One approach would be to redevelop these sections in the same fashion as most of the area – in the ON and elsewhere – now designated as total water control has been developed. This designation can be interpreted to mean that water supply is assured rather than that the control of water is total.[16] In fact, much water is lost and poorly utilized, even within perimeters. Lined interior canals and on-farm land-leveling would significantly reduce losses but would exceed the presently accepted cost of 3.75 to 4.0 million CFAF per hectare. Limiting investment to 4.0 million CFAF per hectare would likely allow only the type of perimeter construction that already exists and that wastes water needed for development elsewhere.

The second, more desirable approach has a higher level of investment in order to at least initiate the type of construction that will soon become imperative as limited water supplies must be used to irrigate more area. Unsophisticated calculations show that up to 7.5 million CFAF could be invested per hectare without exceeding the break-even cost of perimeter construction.

In the case of the Dioro perimeter, the study team was not in a position after one visit to specify an average per-hectare cost of converting over 2,000 hectares to the standard it would recommend. Because existing structures may be useable, some areas may cost no more than 4.0 million CFAF per hectare to convert. Other areas are likely to cost at least 6.0 million CFAF per hectare. The illustrative example below of development costs for *maîtrise totale* over the next 10 years uses an average of 5.5 million CFAF per hectare. This will permit the construction of better perimeters that can be used as models in the future for more efficient and effective water use. At this stage it is not possible to be precise as to exactly what the higher cost will purchase in terms of better water management. That determination is very dependent upon the individual site considered.

16 The closest approximation to real total water control that the study team observed was at Selingué.

However, the type of perimeter that should be targeted is one that utilizes leveled farm plots, a canal system lined to the extent possible with canal gates providing downstream control, duckbill weirs and *modules à masques* precision gates at the tertiary level to provide the possibility of measuring the water utilized.

All the equipment detailed above contributes to increased "total control" such that, given the proper incentive to reduce wasted water, the farmers and the system operators will be able to do so. The farmers can request the water they wish to pay for and the operators of the system will be able to deliver the quantity requested and easily measure the delivered water. Then the system's water managers can base at least a part of the fee charged to the farmers on the quantity actually used. At that point the incentive to use less water becomes functional.

Table 4.1. An Illustrative Table of Estimated Construction Costs (conversion of a site with an assured water source from controlled submersion to *maîtrise totale*)

Year	Additional Area (ha)	Cost/ha (m. CFAF)	Total Cost (m. CFAF)	Total Cost ('000$)	Increased Yield (T/ha)	Cumulative Additional Output (T)	
						Paddy	Rice
2	250	5.5	1,375	2,200	**2**	500	360
3	250	5.5	1,375	2,200	**2.5**	1,125	810
4	250	5.5	1,375	2,200	**3.5**	2,000	1,440
5	250	5.5	1,375	2,200	**4**	3,000	2,160
6	250	5.5	1,375	2,200	**4.5**	4,125	2,970
7	250	5.5	1,375	2,200	**5**	5,375	3,870
8	250	5.5	1,375	2,200	**5**	6,625	4,770
9	250	5.5	1,375	2,200	**6**	8,125	5,850
10	250	5.5	1,375	2,200	**6**	9,625	6,930
Total	2,250			19,800			

Note: Year 1 would be the startup phase: studies to set baseline, identify and evaluate potential sites, carry out the design, etc.

Assumptions:
a) An exchange rate of 625 CFAF to $1.
b) One ton of paddy = 720 kg of rice.
c) Paddy yield will rise from 1.5 to 2 T/ha initially to 7.5 to 8 T/ha.

4.1.2 Desired Outcome from Investment in the Dioro Perimeter

The following is a partial list of the desired outcomes from a well-done conversion of an irrigation system from its present condition of controlled flooding to that of *maîtrise totale*.

- Paddy yield increase of three to four tons per hectare over existing yield of two tons per hectare within four years from project initiation as well as 25 percent of irrigated area planted to dry season crop of potatoes by women's groups from the surrounding villages.
- Establishment of a gravity delivery system with downstream control that assures efficient water management at the on-farm level.
- Farmer fields professionally leveled and designed with infield water use efficiency of 80 percent.

- An increase in household incomes from farming operations of at least 50 percent within three years.
- Establishment of a system of payment based, at least partially, upon quantities of water actually used by the farmer or a group of farmers instead of purely a system user or system access fee.
- Development of comprehensive construction standards for a truly water efficient perimeter based on real "total water control." This entails efficient primary, secondary, and tertiary delivery systems that will pilot the establishment of standards for future rehabilitation and development of new systems for gravity delivery of surface water in Mali. This effort should involve collaboration with the ON and other donors (the Dutch and French in particular) in order to include the best construction techniques.
- A process of collaboration with local villages similar to that provided under the DAD Project, setting the standard for effective participation, farmer organization and self-management of irrigation infrastructure. Farmer participation would begin with project identification.

4.2 Conversion of an Uncontrolled Flooded Area to a Controlled Flooded Area (*Submersion Libre* to *Submersion Contrôlée*)

The strategy of development of the irrigation type known as *submersion contrôlée* is to purposely select from a large area those sites where maximum benefits can be derived with the least investment. In short, the intention is to undertake the easiest and cheapest construction so as to provide benefits rapidly to a large number of people.

The concept of controlled flooding is simple: close the gates to prevent the floodwaters from entering a perimeter if the small rice plants are not yet ready for deep water; let the floodwater in when the time is right and close the gates to retain it at the proper levels until it is opportune to open the gates and let the water drain back to the river. Everything depends upon the height of the floodwater in the river. One in every three to five years, the river high-water level is insufficient to allow an adequate quantity of floodwater to enter the perimeter and therefore there is little or no harvest.

In the districts of Djenné, Ténenkou, Youwarou and Mopti Central, it is estimated that during a normal flood crest of the Niger River, an area of 16,048 square kilometers (1,604,800 ha) or 56 percent of the total Niger Delta area is flooded. The same calculation made during the lowest recorded crest of the Niger results in an area that is 26 percent of the Niger Delta area (7,996 square kilometers or 799,600 hectares).

Under the latter, more conservative estimate, the area available for conversion from uncontrolled flooding to controlled flooding is about 800,000 hectares. Personnel managing the DAD Project have identified some 30,000 hectares in the district of Djenné as having the required potential for development. The proposed areas are:

- Plain of Mangary…………………… 10,000 ha
- Plain of Yongary…………………… 10,000 ha

- Plain of Mourary…………………… 10,000 ha

Other areas of potential development for controlled flooding are:

- District of Ténenkou:……………….30,000 ha
- District of Youwarou……………..… 30,000 ha
- District of Mopti………………........ 10,000 ha

The advantages of those areas selected are as follows.

- The new locations are in an area in which similar construction and organizational technologies have been successful under the DAD Project.
- The cost of construction is estimated to be between $40-300 per hectare with an average of $240 per hectare.
- Areas mentioned are those most likely to receive the benefits of the Niger River flood crest.

4.2.1 Approximate Cost of Proposed Development

In the illustrative table below, the $250 cost per hectare represents 156,000 CFAF. This estimate or “targeted cost” includes only the cost of the construction itself and the activities directly tied to it, both before and afterwards.

Table 4.2. An Illustrative Table of Estimated Construction Costs (conversion of an uncontrolled flooded area to a controlled flooded area)

Year	Area (ha)	Cost/ha (‘000 CFAF)	Total Cost (m. CFAF)	Total Cost (‘000$)	Increased Yield (T/ha)	Cumulative Additional Output (T)	
						Paddy	Rice
2	11,000	156	1,716	2,750	0.5	3,685	2,653
3	11,000	156	1,716	2,750	1	11,055	7,959
4	11,000	156	1,716	2,750	1.5	22,110	15,919
5	11,000	156	1,716	2,750	1.5	33,165	23,879
6	11,000	156	1,716	2,750	2	47,905	34,492
7	11,000	156	1,716	2,750	2	62,645	45,104
8	11,000	156	1,716	2,750	2	77,385	55,717
9	11,000	156	1,716	2,750	2	92,125	66,330
10	12,000	156	1,872	3,000	2	108,205	77,908
	100,000		15,600	25,000			

Note: Year 1 Startup: Studies to set baseline, identify and evaluate potential sites, etc.

Assumptions:
a) 625 CFAF=$1
b) One ton of paddy = 720 kg of rice.
b) Paddy yield will rise from 0.5 T/ha to 2.5 T/ha, but there will be crop failure one year in three. Therefore, 4 tons improvement over 3 years or 1.33 ton/ha/year average increase.
Anticipated total production is 1.67 T/ha/year or 5 T/ha over 3 years.

4.2.2 Desired Outcome of Investment in the Djenné and Mopti Areas

- A large number of farm families will be affected; one farm family for each seven hectares has been typical in the DAD Project.
- If flood crest control is achieved comparable to that of the DAD Project, the area of controlled flooding with improved water control will cover an area 1.8 times greater than that existing before intervention.
- Yields of rice will increase from one-half ton per hectare to two tons per hectare, one crop year after control structures are in place and correctly managed and after new varieties are introduced.
- Village associations will be capable of collective management of irrigation control structures and capable of resolving land disputes.
- Women will benefit from the increased activities associated with processing and marketing of increased rice production and participation in mutual credit associations.

4.3 Bas-Fonds Development

There are considered to be two levels of *bas-fonds* development:

- Small valley bottoms or basins up to 150 hectares; and
- Larger plains, which can be 150 to 1,500 hectares.

The study team recommends the development of some 12,000 hectares of *bas-fonds* of the two types combined over the 10-year period from 2003–2012. The *bas-fonds* thus funded would be located in the area of OHVN and selected parts of Mali-Sud, the CMDT zone.

4.3.1 Small Valley Basins

Approximately 40 percent of the total funds committed to the *bas-fonds* effort should be devoted to the smaller valley basins that utilize a simpler control technology. Construction is usually neither complicated nor very costly, but the sites are scattered and each must be studied to determine the best location and type of structure(s) required. In general, the larger the area that is controlled by a single or main structure, the lower the cost per hectare. The more expensive sites are apt to be those with a single structure affecting only a small area. The most advantageous ones should be selected for development first. For this reason the estimated cost per hectare averages 300,000 CFAF per hectare for the first three years and rises to 600,000 CFAF per hectare in next six years.

Opportunities for support action abound with respect to working with women and communities at large, both to enhance and empower the disadvantaged as well as to assist in development of mechanisms to cope with any conflicts between different segments of the population.

Table 4.3 provides illustrative costs of development for *bas-fonds* in the small valley basin category.

Table 4.3. An Illustrative Table of Estimated Construction Costs (*bas-fonds* development for small valley basins)

Year	Area (ha)	Cost/ha ('000 CFAF)	Total Cost (m. CFAF)	Total Cost ('000$)	Increased Yield (T/ha)	Cumulative Additional Output (T)	
						Paddy	Rice
2	1,000	300	300	480	1	1,000	720
3	1,000	300	300	480	1	2,000	1,440
4	1,000	300	300	480	1	3,000	2,160
5	1,000	600	600	960	1	4,000	2,880
6	1,000	600	600	960	1	5,000	3,600
7	1,000	600	600	960	1	6,000	4,320
8	1,000	600	600	960	1	7,000	5,040
9	1,000	600	600	960	1	8,000	5,760
10	1,000	600	600	960	1	9,000	6,480
	9,000		4,500	7,200			

Note: Year 1 Startup Phase: Studies to set baseline, identify and evaluate potential sites, etc.

Assumptions:
a) 625 CFAF=$1
b) One ton of paddy = 720 kg of rice.
c) The cost per hectare will increase in later years due to early selection of the least costly sites (per hectare) in order to quickly obtain maximum results.
d) Paddy output increases from one T/ha to two T/ha after development.

Notes:
1) Rice is not the only crop produced. The value of vegetable crops is often of equal magnitude to that of rice.
2) Some of the smaller sites (which are more expensive to develop per hectare) may be more attractive in terms of increasing women's income and, as a result, family well-being.
3) A selection process should be established (as in the DAD Project) which will enable choice of the most advantageous sites with respect to low cost per hectare. It may well be that this process will allow the cost per hectare to be considerably less than that estimated in the table. Some 30 *bas-fonds* projects funded by the African Development Bank in early 2002 had construction costs that ranged from $375 to $4,300/ha, the average being 650,000 CFAF/ha or $1,040/ha.

4.3.2 Large Plains

Large plains form a second category of *bas-fonds* that are irrigated using stream flow from the uplands. One such area centers on Kangaba, about 70 kilometers southwest of Bamako. The team visited the large plains of Bancoumana and Keniégué. This is an area in which USAID has already participated in the improvement of rural roads to enhance marketing of surplus agricultural products. The team also visited the plain of Kléla, 35 km north from Sikasso. This plain presents an opportunity to further develop some larger scale rice-growing areas using *bas-fonds* technology. The larger plains, like Bancoumana, Keniégué and Kléla, have interesting potential for further development.

The requirements differ according to the site. Some plains may prove to be easily developed and cost very little per hectare (as was the case with the DAD Project), while for others the irrigation system can be much more complex. A large plain likely involves a larger stream-flow control structure as the area irrigated can be quite large. More interior gates, dikes and canals are apt to be needed in order to distribute the water uniformly. Because each site is unique it is impossible to specify exactly the type of construction that will be required and how much it will cost. The more complex the interior water control system, the higher the cost per hectare.

This type of *bas-fonds* construction will cost up to 2,650,000 CFAF ($4,250) per hectare. Approximately 60 percent of the funding available for *bas-fonds* should be utilized for these larger plains.

Table 4.4. An Illustrative Table of Estimated Construction Costs (*bas-fonds* development for large plains)

Year	Area (ha)	Cost/ha ('000 CFAF)	Total Cost (m. CFAF)	Total Cost ('000$)	Increased Yield (T/ha)	Cumulative Additional Output (T)	
						Paddy	Rice
2	370	2,650	980.5	1,569	2	740	533
3	370	2,650	980.5	1,569	2.5	1,665	1,199
4	370	2,650	980.5	1,569	2.5	2,590	1,865
5	370	2,650	980.5	1,569	3	3,700	2,664
6	370	2,650	980.5	1,569	3	4,810	3,463
7	370	2,650	980.5	1,569	3.5	6,105	4,396
8	370	2,650	980.5	1,569	3.5	7,400	5,328
9	370	2,650	980.5	1,569	3.5	8,695	6,260
10	373	2,650	988.5	1,582	3.5	10,000	7,200
	3,333		8,833	14,134			

Note: Year 1 Startup Phase: Studies to set baseline, identify and evaluate potential sites, etc.

Assumptions:
a) 625 CFAF=$1
b) One ton of paddy = 720 kg of rice.
c) Incremental paddy production rises from 2 T to 3.5 T/ha.

Notes:
1) In reality the increase could be 5 to 6 T/ha as certain of the plains recommended (Bancoumana and Keniégué) have fallen into disrepair, 40 years after establishment, and no longer produce much.
2) A second crop, preferably of horticultural crops, will be important for financial viability.

Table 4.5 provides a quick summary of Tables 4.1 through 4.4. It shows the number of hectares to be developed, an illustrative average cost per hectare of each system, the total dollar cost of investment in each of the four systems, and the additional paddy production to be expected. In descending order, investment in each system covers less area and costs more per hectare. Investment in the combination of four systems would add some 137,000 tons of paddy (over 98,000 tons of rice) to national output, enhance the well-being of women and smallholder farmers, and provide a model for the future construction of efficient water control structures.

Table 4.5. Summary of Construction Recommendations

	Ha	Cost/ha ('000 CFAF)	Cost/ha ($)	Total Cost ('000$)	Total Output Paddy (T/ha)	Previous Output Paddy (T/ha)	Add'l Output Paddy (T/ha)	Add'l Output Paddy (T)	Remarks
Controlled Flooding	100,000	156	250	25,000	2.5	0.5	2	108,205	Crop failure one year in three taken into account
Bas-fonds									
a) small basins	9,000	500	800	7,200	2	1	1	9,000	Value of vegetables not counted but can equal that of rice.
b) plains	3,333	2,650	4,250	14,134	5	1.5	3.5	10,000	
Conversion To *MaîtriseTotale*	2,250	5,500	8,000	19,800	7.5	1.5	6	9,625	
TOTALS	114,583			66,134				136,830	

Note: Additional output is paddy only for a single cropping season.

Box 4.1 Gender

Agricultural incomes earned by women can have a direct impact on poverty and family well-being. The poverty impact will be limited, however, if the neediest women are not among those who gain access to land or to the equipment needed to be a processor.

In the irrigation sub-sector, women are employed on large gravity systems as farmworkers to transplant, weed and winnow rice but are poorly paid and have limited access to farmland for themselves. In places their activity tends to be limited to the off-season. On the Baguinéda perimeter, for example, women often borrow land to grow vegetables or maize. In the Office du Niger, women are responsible for most vegetable crop production in the off-season. Under the Retail Project in the ON, 25 percent of the land was allotted to vegetable crops for women and youth during the off-season, and family income increased dramatically. Such an increase may be infrequent because women often use most of their vegetable income to pay for inputs obtained on credit.

The land access picture improves in the controlled flooding, irrigated village perimeter and small *bas-fonds* systems. In the ORM zone, women have become landholders and in the case of the Bargondaga perimeter, 29 percent of the landholders are women. There are VRES village perimeters farmed entirely by women. Under the DAD project women are heavily involved in rice harvesting, threshing, winnowing, hulling and trade. In the OHVN zone, women now grow rice and vegetable crops on small *bas-fonds* of one to three hectares. Throughout Mali-Sud, women grow rice and vegetables on undeveloped *bas-fonds*. When water control structures are introduced, however, men tend to take over.

Land tenure traditions and lack of access to credit are barriers that keep women from participating more fully in irrigated agriculture, whether as producers, processors or marketers. Donor-supported projects can help women overcome the land tenure barrier by ensuring that the criteria for land allocation either do not discriminate against them or even favor them to some degree. The French-funded Retail project and the European Union's VRES project have shown that it can be done. In each of the systems it supports, USAID should work toward women having equal access to land. A pre-condition to selecting a small *bas-fonds* for development, for example, should be that the women who have been farming it do not lose their right to do so when it has been developed.

USAID can also assist women to qualify for credit by including a women's credit component in each activity. One example is the crop-related credit scheme that the DAD Project initiated to ensure that women involved in rice processing and marketing had sufficient working capital. Women's savings and credit groups were organized and included training in record keeping and the calculation of interest payments as part of the repayment process.

4.4 Proposed USAID Activities over the Next Decade to Support Expansion in Malian Irrigation

In this section we recommend three kinds of activity that either support the irrigation subsector generally or contribute to the development of the human potential in the Office du Niger.

4.4.1 Improved Farmer Access to Certified Seed to Intensify Production on an Expanding Irrigated Area

In order to assure an efficient use of improved irrigation systems, high yielding varieties of cereals and vegetables need to be available to producers in a timely and cost effective manner. Improved varieties are made available for multiplication through a process of variety introduction and research (plant breeding) by various scientific institutions in Mali. The process of varietal improvement has been effective in most cases and has provided appropriate genetic material for multiplication and distribution to Malian farmers.

Multiplication and Distribution of Improved Varieties of Cereals and Vegetables

Traditionally, the National Seed Service (*Service semencier national* [SSN]) has handled the process of seed multiplication for most cereals in Mali. This service is slated to be dismantled and much of its activities undertaken by DNAMR. Currently DNAMR is multiplying rice varieties through a program of farmer seed multipliers. This program is effective when seed prices are high and production from well-managed irrigated conditions can be assured. The system is less desirable, however, when marginal farmers in poorly managed irrigated systems are engaged. The system is even less dependable during periods of great climatic variation if it is dependent on an unreliable source of water.

In the ON, 41 percent of the farmers used certified rice seed from official seed farms while 95 percent of the area was alleged to be planted with the same varieties. Certified seed tends to be used on larger farms. There appears to be much farmer-to-farmer exchange of seed. This is an indication that the structure of the official seed industry does not always meet farmer demand for certified seed.

In a country so heavily dependent on improved varieties to meet expanding production needs, especially as relates to rice production, a national security stock of breeder, foundation and first generation certified seed should be maintained, perhaps with some government subsidy to ensure against catastrophic crop loss. At present, two or three rice varieties dominate in the major irrigated rice producing areas. There should be a larger number of proven varieties available in order to spread the risk should disease overtake one of the dominant varieties.

The Abt *Agricultural Sector Assessment* indicates there are serious structural problems within the local seed industry illustrative of the kinds of problems cited.

- *Seed laws have been enacted without the input of producers and those involved in the commercialization of seed in Mali*. What may be needed to improve this situation is an understanding of the commercial value of the total seed market and of incentives inherent in the system that motivate private sector investment in change.

- *Need for better definition of proper roles of the private and public sector*. The response to this question will vary between counties depending upon the level of the development of the aggregate agricultural economy. Mali may not require the same set of laws and guidelines as required in the context of a larger agricultural economy.
- *Counterproductive farmer-to-farmer exchanges of seeds*. These seed exchanges will take place, laws or no laws. The question to address is what kinds of cost-effective steps can be taken to assure that these exchanges contribute to the overall improved performance of the agricultural economy. It may be that simple seed inspections by well-trained pubic sector personnel, along with an incentive program for private sector purchase and use of small portable seed conditioning equipment, would provide an intermediate solution. This may suffice until such time as the private sector is motivated to provide greater investment in seed multiplication and distribution.
- *Difficulty in establishing profitable vegetable seed production*. Any thoughts of producing stocks of seed for increased vegetable production (e.g. potatoes) should be critically reviewed before the public sector makes investments. There is little record of success in developing economies for the establishment of a profitable vegetable seed program (including potato seed).

If future investments in irrigation depend on a responsive seed multiplication system with cost-effective production, a systematic review of the existing seed multiplication institutions should be carried out immediately. One primary goal of any newly restructured seed multiplication system should be to create a secure source of seed production using a dependable irrigated area exploited by progressive mid- to large-size farmers. In Mali, this may limit the geographic choice of where to establish a seed multiplication industry. At present, the traditional seed multiplication area located in the ON has benefited from years of technical assistance from the Germans and Dutch. Any future attempts to develop a seed multiplication industry might consider building on this past experience and infrastructure. In particular, the focus should be on farmer groups that are better equipped and have established reputations for producing a good product in the past.

Potential Role for USAID in the Office du Niger

The current over-reliance on farmer exchanges of seed is an indication that the supply of good quality rice seed, particularly of high-yielding varieties, needs to be improved and made more secure. The private sector can and should be responsible for rice seed multiplication. The place for it is the Office du Niger, where there is an assured source of water as well as a research station and other resources. Since the ON considers some 25,000 hectares to be available for private sector development, there is more than adequate space for seed multiplication.

We propose that USAID/Mali facilitate the development of mid- to large-scale private sector seed farms. This will place USAID/Mali at the forefront of the effort to induce substantial private investment in the Office du Niger while at the same time ensuring there will be tangible benefits to innumerable smallholder rice farmers around the country.

This activity should be closely coordinated with the PNIR program that intends to fund construction of primary water delivery systems in the ON in order to provide incentives for private sector investment. Entrepreneurs participating in the program will create their own secondary, tertiary and quaternary networks. We propose that USAID support the provision of credit exclusively for development of on-farm delivery systems for private seed production farms. A rotating fund of approximately $2 million would serve the purpose.

The modalities for administering the fund would have to be determined. One of the four financial institutions working in the ON is the National Agricultural Development Bank (BNDA), which has been active there for more than a decade. Through its agency in Niono the bank provides over $100,000 in direct credit annually to 18 farmer organizations and more importantly provides over $1.5 million yearly to farmer groups through intermediary organizations. The capability of the BNDA to administer a large program to support private seed farms needs to be examined. Indeed, this is an occasion for synergy with the forthcoming USAID Financial Sector activity (see Section 4.5)

In any case, it will be better to work with one of the four financial institutions active in the ON rather than create something new. A history of heavy indebtedness incurred by village associations, excessive competition among financial institutions and lack of coordination with project credit schemes has bedeviled the ON in recent years. Credit programs are now enjoying more success, however, and the seed farm credit program should work in harmony with other credit initiatives in the Office du Niger.

In addition to their primary role of producing adequate quantities of certified seed, the farms supported by USAID could pioneer new approaches that use water more efficiently. For example, as a condition for receiving credit, the seed farms should be given technical assistance in land leveling, be required to line certain canals with cement and be obliged to install modular mask gates to measure the quantity of water actually used. At the same time, the ON should be encouraged to base a significant part of the *redevance* paid by these farmers upon the quantity of water consumed by them.

4.4.2 Rehabilitation of Small Farmers in the ON

Many farmers in the ON are impoverished. Some who are unable to pay their *redevance* begin borrowing money and become heavily indebted. This is most evident when considering the living conditions of those most recently losing land and joining the labor force in Niono.

These individuals are likely to be from one of the following situations:

- Rice farmers expelled from the unimproved areas adjacent to the ON;
- Share croppers and immigrants;
- Rice farmers who are under equipped, do not have enough family labor and are obliged to sell their crop before harvest, losing any profit; and
- Landless farm workers, among are a large number of women, seasonal migrants (Bellas and Dogon) and *talibés*.

In order to improve the productivity of these groups and increase rice production in the ON, the following activities could be promoted by USAID:

- Increased technical training on improved cropping in conjunctions with water-saving techniques;
- Improved primary health care and water supply and sanitation facilities, in collaboration with the new Cercle Level Health Initiative;
- Promotion of savings and credit schemes to facilitate the purchase of equipment and increased inputs, in collaboration with the new Strengthening the Financial Sector activity;
- Assuring secure access to a dependable supply of HYVs;
- Farmer training for improved management of financial resources;
- Activities to organize, strengthen and empower water-user associations (WUA);
- Training for WUA leadership in techniques needed for improved negotiation with input suppliers and the ON administration; and
- Training for WUA leadership in non-conflictive ways to eliminate corruption and mismanagement.

These activities would broaden the focus of USAID's existing programs to ensure the development of the human potential resident in the ON in order to contribute to a successful expansion of rice production for Mali.

4.4.3 Promote a Research and Training Center for Improved Irrigation Technology

Currently a low level of applied research on improved irrigation technology exists in Mali. Historically this source of improved technology has come from programs such as IER's efforts in soil/water/plant research and Dutch-funded ON programs (BEAU and GEAU), all of which began in the 1980s and have been completed. The Private Irrigation Promotion Project (PPIP*)* is currently carrying out a limited program of adaptive research whose focus has been on small-scale irrigation technology for wells (i.e., the pedal pump), low-cost well drilling, and motor pump testing.

There is an irrigation research and training center in Burkina Faso where Malian irrigation engineers go for short-term training. It would appear, however, that Mali's systems of water management are far more complex and require much greater investment than systems in Burkina Faso. If this is the case, an argument can be made that a regional research and training center in Mali focusing on gravity systems delivering water via elaborate canal networks would better serve the needs, not only of Mali but also of Senegal, Guinea and even The Gambia. The Burkina Faso center could then be relied upon to provide training in small *bas-fonds* and other water harvesting systems.

As the next decade of irrigated production begins in Mali, its farmers and policymakers will require access to data on water use, improved methods of irrigation and water management. At a minimum, the following kinds of information concerning irrigation and water use in Mali must be available:

- Analysis of performance at the producer level of the different types of irrigation available in Mali, aided by diligent monitoring of the systems;
- Plant-water requirements under the diverse growing conditions and irrigation methods practiced in Mali;
- Costs of irrigation system development using effective methods of construction for water conserving techniques such as land leveling and canal lining as well as costs for gates and irrigation structures such as protection dikes; and
- Financial and economic analysis to determine the comparative advantage of different systems of irrigation.

An important aspect of future irrigation research would be the adaptive phase of testing innovations in collaboration with farmers on their farms under actual production conditions. This type of research would have a wider audience in the region and could provide a dynamic database for improved water use and conservation of natural resources. The effort could be aided with long-term funding by other national governments in the region and international organizations such as the CGIAR/World Bank. USAID support of a regional Irrigation Training Center could influence the CGIAR/World Bank and the African Development Bank to provide initial funding. USAID has played a similar role in the establishment of centers for irrigation research in Asia.

4.5 Synergy with Other USAID Activities

An irrigation subsector activity under the Intermediate Result for Sustainable Production of Selected Agricultural Products (IR 1) would begin at about the time as other new activities in the mission's portfolio. These include Trade Promotion and Strengthening the Financial Sector, which are the other two IRs under the Accelerated Economic Growth Strategic Objective. An irrigation activity would also coincide with the Cercle Level Health Initiative and Consolidating Mali's Decentralized Governance.

There will be many opportunities for synergy between the irrigation initiative and these activities. Certainly, work to increase irrigated rice and horticultural crop production should mesh with trade promotion activity seeking export markets in the sub-region for these crops. There will also be many openings to work with the financial sector activity. In Section 4.4 above we cite two areas in which the initiatives in irrigation and finance can help each other. With regard to health, the end of Section 2.1.2 mentions irrigation-related health problems in the Office du Niger, including poor water supply and sanitation in Niono. These conditions could be jointly addressed by the two activities.

Less obvious are the possibilities for interaction with the decentralized governance activity. Two ways in which the activities could collaborate come to mind. First, one of the unresolved questions in the Office du Niger is the role that the elected commune governments will play vis-à-vis the Office itself. For many years the ON was *de facto* the governmental authority in its domain, providing public services as well as directing who could farm what and where. That era is over, but the ON still retains important prerogatives that could clash with those of the recently empowered communes.

At present it is a very unequal contest, yet over the next few years there will be many occasions when those working on USAID's decentralized governance and irrigation activities can together collaborate with elected commune leaders and ON officials to smooth the transition. The multiple issues to be addressed include natural resource management planning (e.g. fuelwood), sanitation, solid waste disposal, primary health care, and systems for the resolution of conflicts over shared resources. In this section of the report we propose that the irrigation activity help in creating and building up the capacities of effective water user associations. This is precisely the kind of civil society organization that needs an elected local government unit as a partner so that together they can accomplish things that neither one could do alone.

Second, outside of the Office du Niger, in areas with controlled flooding or *bas-fonds* systems, implementers of the irrigation activity can find occasions to work with those implementing decentralized governance. As an example, under the DAD project relationships between municipal councils and inter-village producer associations have been fostered. Several councils have included DAD-type water management infrastructure in their development planning.

An increasingly important issue affecting both irrigation and local governance will be conflicts between farmers, fishermen and livestock herders over access to natural resources – land and water. It is vitally important that citizen's groups and their elected officials understand these issues and become effective decision makers regarding them. Otherwise the risk is great that these resources will be exploited by outsiders for their own benefit.

Appendices

The *Office du Niger*

In basic outline, the story of the Office du Niger (ON) is well known. In 1919-1920, when France was anxious to find a secure source of cotton for a textile industry almost totally dependent on imports, Emile Bélime led a commission to study the irrigation potential of the Niger valley. The commission concluded that irrigated could cover about a million hectares, which would nicely meet France's needs for raw cotton. However, when the governor of French West Africa advocated instead a policy to prevent famine, a consensus emerged in Paris that one half of the irrigable land would be devoted to cotton production and the other half to rice.[1]

Creation of the Office du Niger

By 1929 Bélime had completed the design for irrigating 960,000 hectares in the "dead" delta of the Niger. Two years later the French National Assembly approved construction of a diversion dam at Markala and the primary canal network. By 1935 some 11,000 hectares in the lower sector (*Kala Inférieur*) around Niono had been developed physically and could be irrigated. What was lacking was labor. The area was underpopulated and had to be settled. By 1937 the first farmers, most of them more or less forcibly recruited in the territory of Upper Volta, had arrived. Being settlers, they were called *colons.* Eventually 300,000 would come from Upper Volta. Others came from within Mali.

The ON itself was created in 1932 as a public enterprise. The *colons* were given housing, draft animals, plows, harrows, seed and prepared land, but it was all on credit, which the beneficiaries were obliged to reimburse in kind. In fact, from their harvests they kept just enough for food and seed and had to surrender the rest. Cooperatives run entirely by the ON supplied equipment, seed and fertilizer. Disappointing results led in 1942 to a radical scaling down of the grand design for the ON. Instead of 960,000 hectares, the objective was cut to 160,000 hectares, which were to be developed within ten years.

By the end of World War II, only 25,000 hectares were being irrigated, and many of the farmers were finding working conditions both difficult and very different from what they had known. They were separated from their extended families and were obliged to do exactly as the ON dictated. Many of the Mossi from Upper Volta departed.

To build the Markala dam the French authorities forcibly recruited 2,000 workers, who labored under extremely harsh conditions, a number of them dying in the process. There is a monument to them near the dam. Major work on the dam was completed by 1945 and two years later it began to operate.

Beginning in 1949, with help from Marshall Plan funds, the ON decided to resolve some of its problems by mechanization. Workers were hired and paid wages to work on 5,600 hectares in the Molodo zone. To amortize the heavy investment in mechanization, yields of at least three tons per hectare would have been required, but in reality yields did not exceed 1.5 tons for

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[1] This historical section is heavily based on Emil Schreyger, "La période 1932-1982: De la 'mission Bélime' à l'Office du Niger" in *L'Office du Niger: Grenier à riz du Mali.*

technical and climatic reasons. The mechanization effort continued until Mali gained its independence in 1960 but was clearly a failure.

The Malian government, having chosen a "socialist option," nationalized the ON in 1961 and replaced foreign staff with Malians. Part of the irrigated area was turned into state farms with collective fields where workers were paid wages and allowed to cultivate half a hectare for their family's needs. The government controlled prices and heavily subsidized rice production in the ON. With the Malian franc no longer backed by the French franc, spare parts for machinery became very scarce. By 1968 the results of these policies were clear. Output of rice and cotton had fallen by 25 percent since 1960.

In one area, however, there were some positive developments. China introduced sugarcane and built the first of its two sugar mills at Dougabougou in 1965. Using wage labor and hiring seasonal cane cutters from around the country, the sugar complex proved to be successful. The cultivated area grew to 2,000 hectares in the space of 14 years, and more than 5,000 people settled the area voluntarily.

After the overthrow of Modibo Keita in 1968, the new government abolished the collective fields, turned the cooperatives into strictly commercial operations and ended the cultivation of cotton. Rice production grew by 50 percent between 1967 and 1974. This turned out to be providential, for the ON was increasing production while rainfed harvests were failing all around it in the great drought of the early 1970s. Not surprisingly, the drought induced more farmers to settle in the ON. Among them was a second wave of Mossi settlers from Burkina Faso in the mid-1970s. At that time farmers began to cultivate crops outside the perimeters (*hors casier*).

Declining Performance Leads to Change

In 1978 the ON succeeded in producing 101,000 tons of paddy, a record, as a result of heavy government outlays for fertilizer and equipment, along with good extension work and a 60 percent increase in the producer price. The increase in output was deceptive, however. Production fell back to around 60,000 tons in subsequent years as neglected maintenance of infrastructure, soil degradation, and the financial problems of the state agency that purchased all of the ON's rice took their toll.

The ON was still responsible for everything, including land development for irrigation, provision of inputs and credit, operation and maintenance of the entire irrigation network, and crop processing and marketing, not to mention housing, health care and education services. It became clear that the system had to be changed.

In 1982 there were more than 55,000 people farming 35,000 hectares of rice and sugarcane fields. The ON was producing 80 percent of the rice marketed in Mali. However, the cultivated area had declined from almost 41,000 hectares in 1974; output had fallen all the way to 56,500 tons; and average yield had slipped badly from 2.7 tons in 1977 to only 1.6 tons. Table A.1 provides a clear picture of how performance declined from the mid-1970s to 1982 and then rebounded with perimeter rehabilitation, the use of better practices (transplanting and more fertilizer), and implementation of liberalization measures.

Table A.1. Office du Niger Indicators, 1974-2001, Selected Years

Crop Year	Area (ha)	Area Transplanted (ha)	Production (T)	Yield (T/ha)	Area Rehab. (ha)	Fertilizer Use (T)*
1974/75	40,774		86,000	2.11		
1977/78	37,946		101,000	2.66		
1980/81	35,589		69,290	1.95		
1982/83	35,181		56,524	1.61	450	
1984/85	38,154	37	64,086	1.68	3,778	
1987/88	42,125	1,857	98,194	2.33	9,617	
1990/91	43,872	6,766	143,938	3.28	12,452	
1993/94	45,442	25,893	222,634	4.90	18,455	8,932
1996/97	47,984	45,222	246,112	5.29	22,174	12,887
1998/99	49,680	48,741	298,123	6.00	29,740	12,285
2000/01	52,995	52,060	325,300	6.14	29,740	20,294
2001/02	54,404		332,078	6.10	29,740	18,952

SOURCE: Office du Niger

*Urea and DAP (18-46-0)

The figures in the table above concern rainy season rice production on the traditional perimeters of the ON, both rehabilitated and not rehabilitated. They do not include off-season production on the same perimeters, nor production outside the perimeters (*hors casier*), nor the 5,800 hectares of sugarcane managed independently by SUKALA, nor 3,000 hectares within the boundaries of the ON that are irrigated by controlled submersion and managed by Office Riz Ségou. Statistics for off-season cultivation and production outside the perimeters are shown in Table A.2. In the last two years production has increased significantly.

Table A.2. ON Rice Production Off-Season and Off-Perimeter, 1994-2001

Crop Year	Area Double-Cropped (ha)	Production (T)	Area Off-Perimeter (ha)	Production (T)
1994/95	947	3,315	2,702	4,856
1995/96	1,877	6,438	3,107	7,399
1998/97	1,034	2,068	6,502	18,205
1997/98	1,898	7,061	4,562	9,996
1998/99	1,840	8,917	3,594	10,811
1999/2000	392*	2,190	3,995	13,263
2000/01	5,218	19,435	5,825	20,387
2001/02	6.465	27,007	5,185	20,059

SOURCE: Office du Niger

* In 1999/2000 there was no off-season production in the Niono and N'Débougou zones because of maintenance on a drainage canal.

Social services in the ON, notably healthcare, had also deteriorated very badly by the late 1970s. To remedy this situation as well as counter the ON's economic and physical deterioration, the government turned to donors for assistance. The Netherlands began aiding the ON in 1979 with studies of water needs and management, and this led to the first of four phases of the ARPON project, whose initial objective was to raise the living standards of ON farmers by giving them open access to the means of production and to profitable post-harvest activities. The Netherlands were soon joined by France and the World Bank and later by Germany and the European Union. Over a 15-year period the Netherlands funded the rehabilitation of almost 11,500 hectares and took a number of other initiatives to improve the performance of the ON. France has also been very active in the rehabilitation of infrastructure (see Table 2.1).

To obtain commitments from donors, the GRM was obliged to curtail the so-called economic police that had been harassing farmers, to raise the producer price for rice and to diversify sales away from OPAM, the state monopoly. By 1985 further loosening occurred with decisions to decentralize ON management, change land tenure rules, liberalize rice marketing and transfer responsibility to farmer organizations. The Office signed a contract-plan with the GRM in 1988 and was obliged to reduce the number of its employees from 4,000 to 2,000. Decentralization took effect by making certain units autonomous, including the seed farm and the farm equipment assembly shop that had been created with Dutch assistance.

The New Office du Niger Takes Shape

On the eve of the devaluation of the CFA franc in January 1993, the GRM suspended preparation of a new contract plan and created a special office for the reorganization of the ON attached to the Prime Minister's office. In concert with its development partners (the donors), the Government agreed to create joint ON-farmer committees for system management and land allocation. The declared intention was to give farmer groups full responsibility for land allocation eventually. The result of the reorganization effort was a new law, promulgated in March 1994, which changed the legal status of the ON to a public industrial and commercial establishment. An immediate consequence was the reduction of ON staff to 350, all categories of employee included. The Office du Niger also privatized its four rice mills since they could no longer compete with private millers.

The contract-plan of December 1995 was signed by three partners instead of two. Farmer representatives signed along with representatives of the GRM and the ON. The contract plan committed the government to providing the financing that might be required to fulfill its duties in the national interest. For its part, the ON committed to implementing programs to develop its irrigation system further, within fixed budgets and subject to the monitoring of performance indicators. The farmers' representatives agreed to operate and maintain the tertiary canal network, to follow recommended agricultural practices and to be responsible for their own marketing of rice.

Since 1982 the ON has thus been transformed from what was described as a "state within a state" to a supervising manager with much less involvement in production, processing and marketing. The ON's role is now limited to management of the land allocation process, supplying water to the irrigation network, maintenance of the major water distribution structures along with the primary and secondary canals, and extension services (*conseil rural*). Despite the great progress that has been made, concerns about the future course of the Office du Niger still linger. As indicated earlier in this report, they have come to the fore in the process of developing a master plan for the ON.

The ON still retains certain prerogatives, such as the allocation of land, and the donors who have invested very large sums in the rehabilitation and reorganization of the ON are looking for further easing of ON control before they make additional commitments.

Donor Concerns about the Office du Niger

After sitting in as observers at a meeting of the Monitoring Committee for the ON contract-plan in January 2002, the major development partners[2] for the ON expressed their concerns in a joint letter dated February 11, 2002. The letter was addressed to the Minister of Rural Development, the Minister of Economy and Finance, the President Director General of the Office du Niger and representatives of ON farmers. The issues may be summarized as follows.

1. The ON master plan (*schéma directeur*) should be finalized as soon as possible so as to bring up to date the strategic thrust of the ON;

2. Realistic, quantified objectives are needed for the contract-plan. Merely listing indicators is not sufficient;

3. In order for the government to disengage from maintaining the primary networks, it should make good on its prior commitment to study the ability of farmers to pay, so that a realistic system user fee (*redevance*) can be established;

4. If a user fee is to be applied to the tertiary networks, it should be based on empowerment of farmers in a framework developed with them;

5. The ON and farmer representatives should take into account the guiding principles of the PASAOP project relating to the organization of farmers;

6. Improving the quality of farmer representation is extremely important;

7. More secure land tenure for smallholders, who make up about 65 percent of the total, is equally important;

8. Further clarification is needed on several issues concerning the system user fee, and there should be more transparency on the elements that go into the fee; and

9. Development partner assistance should be mobilized not only for the development of new perimeters but also for perimeter rehabilitation and particularly for support to farmers and their organizations.

The Ministry of Economy and Finance provided a response on each of these points to the development partners.

[2] The major donors (development partners) are the European Union, France, the Netherlands, the U.S. and the World Bank.

The donors also participated in a national workshop on the elaboration of the master plan in July 2001 but were not satisfied that it clarified scenarios for the Government's plan to develop 120,000 new hectares in the ON by the year 2020. Concerns over the way in which the Office du Niger master plan was evolving prompted the development partners to send a second letter to the Minister of Rural Development on February 11, 2002. It asked that the Malian authorities be more specific about policy orientation and institutional change concerning the following points.

1. The creation of water user associations and consolidation of producer organizations;

2. Adaptation of extension services in light of changes underway;

3. Land tenure policy;

4. Choice of farm units to be promoted (family farms or agricultural enterprises) and of support to be provided to them;

5. Modification of the role of the Office and the commitment of the Government to carrying out change; and

6. Weighing investment in new versus rehabilitated perimeters.

At the 2001 workshop there also appears to have been donor dissatisfaction with the conclusions of a consultant's report on the first phase of master plan development. As a result, a second consultation was funded by France and entrusted to a well respected individual. His report was to be studied by interested parties in December 2002, leading up to a workshop in January 2003, where the development partners would participate in the elaboration of terms of reference for a second phase in the development of the master plan.

One of the major donors believes that the difficulties engendered by the 2001 workshop and the first consultant's report should be overcome by the second consultant's work. While this may mean that the master plan is back on track, the same development partner believes that several studies will be required in the second phase. The topics might include:

- Land tenure;
- Standards for efficient water use;
- Improvements in living conditions for farm families (e.g. health care and potable water);
- Transfer of irrigation management to water user associations; and
- Transparency about land transactions – i.e. determining what actually occurs and perhaps legalizing land sales so that a land market is allowed to develop.

A number of questions about the Office du Niger and its future thus remain unanswered.

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Appendix C: Statistical Tables

Table C.1. National Paddy Production, Last 16 Years

CropYear	Production (T)	CropYear	Production (T)
2001-2002 (e)	840,051	1993-1994	427,609
2000-2001	742,599	1992-1993	410,018
1999-2000	727,140	1991-1992	454,349
1998-1999	717,856	1990-1991	282,366
1997-1998	575,745	1989-1990	337,749
1996-1997	627,405	1988-1989	287,797
1995-1996	476,090	1987-1988	236.568
1994-1995	469,127	1986-1987	225,138

SOURCE: MDR, Bilan de la Campagne Agro-Pastorale 2000-2001, Oct. 2001 ; also in MDR, Recueil des Statistiques Rurales, March 2001.

Table C.2. Estimated Paddy Production by Region, Crop Year 2001-2002

Region	Production (T)	Region	Production (T)
Kayes	2,416	Mopti	124,126
Koulikoro	26,994	Timbuktu	92,780
Sikasso	98,761	Gao	24,359
Segou	470,616	**TOTAL**	840,051

SOURCE: MDR, Bilan de la Campagne Agro-Pastorale 2000-2001, Oct. 2001

Table C.3. Paddy Production by Region, 1990-1999

Year	Kayes	Koulikoro	Sikasso	Ségou	Mopti	Timbuktu	Gao
1999-2000	2,638	25,599	119,194	396,902	88,271	78,702	15,834
1998-1999	594	37,638	91,408	389,784	134,461	46,951	17,020
1997-1998	1,055	35,952	87,289	348,841	46,174	38,682	17,752
1996-1997	3,480	30,418	76,244	339,780	109,401	58,631	9,451
1995-1996	3,846	19,991	65,855	283,069	67,865	28,589	6,875
1994-1995	3,437	17,431	61,324	234,390	102,706	42,159	7,680
1993-1994	2,621	18,016	57,604	238,752	63,687	35,925	11,004
1992-1993	2,171	14,548	50,223	218,645	67,882	43,317	13,232
1991-1992	8,535	22,472	54,102	219,966	81,953	51,568	15,753
1990-1991	531	8,301	13,225	153,534	56,272	38,592	11,911

SOURCE:MDR, Recueil des Statistiques Rurales, March 2001.

Table C.4. Producer and Retail Prices for Rice, 1989-1990 to 1999-2000

Crop Year	Producer Price (Paddy) CFAF/kg	Retail Price (Rice) CFAF/kg
1999-2000	122	241
1998-1999	113	254
1997-1998	104	229
1996-1997	177	240
1995-1996	203	263
1994-1995	196	242
1993-1994	147	190
1992-1993	119	162
1991-1992	121	168
1990-1991	146	191
1989-1990	143	201

SOURCE: MDR, Recueil des Statistiques Rurales, March 2001.

Table C.5. Area Cultivated and Production of Various Crops, 1990 to 2001

Year	Wheat		Sugarcane		Potatoes		Shallots/Onions		Tomatoes	
	Area (ha)	Prod. (T)	Area (ha)	Prod. (T)	Area (ha)	Prod. (T)	Area (ha)	Prod. (T)	Area (ha)	Prod. (T)
1990	1,723	2,066	4,559	308,882			1,092	3,976	397	1,519
1991	1,270	2,540	4,747	312,237			9,666	6,461	399	7,278
1992	898	1,256	4,296	274,655			949	20,932	331	8,139
1993	715	2,210	4,294	284,444			1,598	32,790		
1994	1,628	2,650	3,350	262,333						
1995	2,923	6,150	4,002	293,238						
1996	1,607	3,159	4,009	284,638						
1997	2,133	2,720	3,953	302,982	2,083	26,142	3,903	59,523	836	17,201
1998	2,655	6,630	3,991	318,556	2,234	24,895	2,756	42,336	1,397	24,048
1999	3,454	7,528	3,979	291,327	740	10,056	3,367	63,927	984	19,516
2000	2,589	6,114	3,928	312,992	4,268	161,632	2,193	80,189	2,497	43,446
2001	3,580	9,065	4,176	285,235	5,864	115,148	3,500	108,295	27,988	62,587

Table C.6. Illustrative Budget for the Development of 2,002 Hectares in the ON

DESIGNATION	TOTALS FOR 2002 HA (CFAF)	TOTALS PER HA (CFAF)	PERCENT OF TOTAL (CFAF)
1. Primary			
a) Land clearing	348 200 000		
b) Construction of primary canal	1 062 355 000		
c) Construction of primary drain	572 000 000		
d) Road construction	120 000 000		
e) Irrigation structures	235 498 000		
f) Gates & installation	962 985 000		
Total primary	**3 301 038 000**	**1 648 870**	**44.7**
2. Secondary			
a) Land clearing	348 200 000		
b) Construction of secondary canals	895 236 000		
c) Construction of secondary drains	268 400 000		
d) Road construction	96 000 000		
e) Irrigation structures	215 957 000		
Total secondary	**1 823 793 000**	**910 985**	**24.0**
3. Tertiary			
a) Land clearing	348 200 000		
b) Construction of teriary canals	524 865 000		
c) Construction of tertiary drains	81 105 000		
d) Road construction	243 500 000		
e) Irrigation structures	177 734 000		
f) Development of parcels	882 650 000		
Total tertiary	**2 258 054 000**	**1 127 899**	**30.6**
GRAND TOTAL	**-**	**3 687 754**	**100**

Table C.7. Per Hectare Profitability of a Controlled Flooding System Converted to Total Water Control (*Maitrise Totale)*
(in '000 CFAF unless otherwise indicated)

Year(s)	Capital Items	Operation & Maintenance	Cost of Wet-Season Production	Cost of Off-Season Production	Total Cost	Wet Season Output (T)	Sale Price (per T)	Gross Benefit Wet Season	Off-Season Output (T)	Sale Price (per T)	Gross Benefit Off-Season	Total Gross Benefit	Net Benefit
1	5,500	0	0	0	5,500	0		0	0		0	0	-5,500
2	0	0	300	210	510	3.5	120	420	3.5	100	350	770	260
3	0	20	300	210	530	4	120	480	3.5	100	350	830	300
4	0	20	300	210	530	5	120	600	4	100	400	1000	470
5	0	20	300	210	530	5.5	120	660	4	100	400	1060	530
6	0	20	300	210	530	6	120	720	4	100	400	1120	590
7	0	20	300	210	530	6.5	120	780	4	100	400	1180	650
8	0	20	300	210	530	6.5	120	780	4	100	400	1180	650
9	0	20	300	210	530	7.5	120	900	4	100	400	1300	770
10-20	0	20	300	210	530	7.5	120	900	4	100	400	1300	770

Notes: IRR = 9%

a) High cost of development is attributable to canal-lining, field leveling and precise water control (see section 4.1.1).
b) A reduction of development cost to 3.7 million CFAF (see Table C.6) would increase the IRR to 14%.

Assumptions:

a) As assumed in Table 4.1, Year 1 is the start-up phase, which will proceed in tandem with construction.
b) Paddy yields increase over time as assumed in Table 4.1.
c) A second crop of onions is grown on 25% of the area in the off-season. As more area is cultivated in the off-season, the IRR will rise.

Table C.8. Per Hectare Profitability of a DAD-Type Partial Control System
(in '000 CFAF unless otherwise indicated)

Year(s)	Capital Items	Operation & Maintenance	Cost of Wet Season Production	Total Cost	Wet Season Output (T)	Adjusted Wet Season Output (T)	Sale Price (per T)	Gross Benefit	Net Benefit
1	156	0	0	156	0	0		0	-156
2	0	0	68	68	1	0.67	120	80	12
3	0	6	68	74	1.5	1	120	120	46
4	0	6	68	74	2	1.33	120	160	86
5	0	6	68	74	2	1.33	120	160	86
6	0	6	68	74	2.5	1.67	120	200	126
7-20	0	6	68	74	2.5	1.67	120	200	126

Assumptions: IRR = 43%

a) As assumed in Table 4.2, Year 1 is the start-up phase, which will proceed in tandem with construction.
b) The "Adjusted Output" column takes into account crop failure one year in three.
c) No off-season cultivation is assumed.

Table C.9. Per Hectare Profitability of a Pump Irrigation System
(in '000 CFAF unless otherwise indicated)

Year(s)	Capital Items	Operation & Maintenance	Cost of Wet Season Production	Total Cost	Wet Season Output (T)	Sale Price (per T)	Gross Benefit	Net Benefit
1	1,000	0	0	1,000	0		0	-1000
2	0	0	300	300	6	120	720	420
3	0	30	300	330	6	120	720	390
4-10	0	30	300	330	6	120	720	390

Assumptions: IRR = 28%

a) Cost of development is the median cost for the VRES perimeters (see section 2.3.1).
b) Average yield as claimed by the VRES project.

Table C.10. Per Hectare Profitability of a Small Basin *Bas-fonds* System
(in '000 CFAF unless otherwise indicated)

Year(s)	Capital Items	Operation & Maintenance	Cost of Wet Season Production	Cost of Off-Season Production	Total Cost	Wet Season Output (T)	Sale Price (per T)	Gross Benefit Wet Season	Off-Season Output (T)	Sale Price (per T)	Gross Benefit Off-Season	Total Gross Benefit	Net Benefit
1	500	0	0	0	500	0		0	0		0	0	-500
2	0	0	50	200	250	2	120	240	2.5	100	250	490	240
3	0	7	50	200	257	2	120	240	2.5	100	250	490	233
4-10	0	7	50	200	257	2	120	240	2.5	100	250	490	233

Assumptions: IRR = 32%

a) As assumed in Table 4.3, Year 1 is the start-up phase, which will proceed in tandem with construction.
b) Cost of development is the average cost for the program proposed in Table 4.3.
c) A second crop of onions is grown on 25% of the area in the off-season.

Table C.11. Per Hectare Profitability of a Large Plain *Bas-fonds* System
(in '000 CFAF unless otherwise indicated)

Year(s)	Capital Items	Operation & Maintenance	Cost of Wet Season Production	Cost of Off-Season Production	Total Cost	Wet Season Output (T)	Sale Price (per T)	Gross Benefit Wet Season	Off-Season Output (T)	Sale Price (per T)	Gross Benefit Off-Season	Total Gross Benefit	Net Benefit
1	2650	0	0	0	2,650	0		0	0		0	0	-2650
2	0	0	100	200	300	3.5	120	420	3.5	100	350	770	470
3	0	15	100	200	315	4	120	480	3.5	100	350	830	515
4	0	15	100	200	315	4	120	480	3.5	100	350	830	515
5	0	15	100	200	315	4.5	120	540	3.5	100	350	890	575
6	0	15	100	200	315	4.5	120	540	3.5	100	350	890	575
7	0	15	100	200	315	5	120	600	3.5	100	350	950	635
8-20	0	15	100	200	315	5	120	600	3.5	100	350	950	635

Assumptions: IRR = 18%

a) As assumed in Table 4.4, Year 1 is the start-up phase, which will proceed in tandem with construction.
b) A second crop of onions is grown on 25% of the area in the off-season.